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ARCHIVES OF SURGERY

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AUTOMOBILE INJURIES

A STUDY FROM RECORDS OF POSTMORTEM EXAMINATIONS *

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This survey deals with the injuries found by postmortem examination of the bodies of 383 persons killed by motor vehicles. The accidents all occurred between the summer of 1911 and the autumn of 1924 (table 1). Those who lived to arrive at the hospital were all cared for at the Cook County Hospital. There were forty-five boys and fifteen girls from 4 to 15 years of age; of older persons, there were 272 men and fifty-one women. The number injured by trucks was forty-seven; by taxicabs, thirty-five, and by automobiles, 301. It was learned that one

TABLE 1.—*Data of Three Hundred and Eighty-Three Accidents According to Years* *

Year	Number	Year	Number
1911	5	1918	30
1912	2	1919	32
1913	12	1920	46
1914	9	1921	56
1915	8	1922	56
1916	11	1923	55
1917	28	1924 (January to August)	33

* There was no appreciable increase in accidents during the summer months.

man fell from a truck which then passed over his body; two others were knocked down and then run over by trucks; one man who was sitting on a curbstone was hit by a passing machine; two were crushed between automobiles and street cars, and a third between a car and the wall of a viaduct.

Except for a few such details, information about the accidents available at the time of the necropsies was vague, insignificant or altogether wanting. Apparently, as a rule, attempts to hide the truth begin immediately with these accidents and are continued throughout the medicolegal inquiries. Consequently, evidence about the attending circumstances is of little value in explaining the injuries; it certainly has no validity comparable with that derived from the postmortem examinations. Although our account is concerned solely with the bodies of those whose

* Submitted for publication, Dec. 1, 1928.

* From the Norman Bridge Pathological Laboratory, Rush Medical College.

injuries were fatal, it is fair to assume that injuries more serious than those received by some of these persons resulted during the same period from similar accidents to others, who recovered either partially or completely in the Cook County Hospital. Their number and other details about them are altogether without the scope of this presentation, but similar accidents are being repeated, in urban populations especially, in steadily increasing numbers.

It is hoped that this account may have some practical usefulness in the care of persons injured in similar accidents. By surgeons accustomed to handling these emergencies, our difficulty will be promptly appreciated; namely, the lack of any feasible way of passing in review for the reader the conditions as they were met by postmortem examinations, body by body, and day after day, so that they would be easily visualizable. To such surgeons, this defect will be especially noted in the absence of much reference to external injuries. Consequently, we have been compelled to use tables and to discuss the injuries in groups. We believe, however, that careful reading will disclose to some degree the manner in which the injuries of different structures were associated in single bodies. We have made only casual reference to the extensive literature regarding many of the injuries in these groups, because it contains so little directly related to accidents caused by motor vehicles.

FRACTURES OF THE SKULL

Location of Fractures.—The fractures were in the vault in seventy-seven bodies (34.37 per cent), in the posterior fossa in forty-four (19.64 per cent), in the middle fossa in twenty-eight (12.50 per cent), in the anterior fossa in twenty-three (10.26 per cent) and in fifty-one bodies (22.76 per cent) they were so extensive that classification was impracticable; in one, only the right zygomatic arch and nasal septum were broken.

With the cranial fractures, the nasal bones were broken in eight bodies, the mandible in ten, the zygoma in nine, the upper maxilla in five and the malar bones in three. In some of the bodies with broken bones of the face, there were various combinations: a broken mandible and zygoma or broken nasal and malar bones.

Length of Cranial Fractures.—The length was measured in 151 bodies (67.71 per cent). In thirty-seven with extensively comminuted bones, the shortest total length was 25.2 cm. and the longest, 168 cm., the average being 71.56 cm. In the remaining 114, the shortest was 2.35 cm., the longest 72.7 cm. Diastasis of the sutures, which was present in 14.69 per cent, was a little more frequent with fractures of the vault.

Sites and Degrees of Injuries of the Brain.—In tables 2 and 3 are summaries of the injuries to the brain, with the fractured craniums and their distribution. In the records of the examination of three bodies

with fractures of the vault and one with fractures of the bones of the middle fossa, some details of the injuries to the brain were omitted; information regarding these brains is not included in the tables. The only change of the brain was edema which occurred with five broken craniums, with four fractures in the middle fossa and with one fracture in the back fossa. Traumatic hemorrhage was present in the leptomeninges; the brains were unbruised in six bodies, five with fractures of the front fossa and the other with fracture of the vault.

In the body referred to in which the right zygomatic arch and nasal septum were broken but in which cranial fracture had not occurred,

TABLE 2.—*Injuries of the Brain with Two Hundred and Nineteen Fractured Craniums*

Location of Fracture	Total Number	Direct Injuries*		Contrecoup Injuries		Both	
		Number	Per Cent	Number	Per Cent	Number	Per Cent
Vault	73	16	21.91	57	78.08	..	.....
Anterior fossa	18	10	55.55	4	22.22	4	22.22
Middle fossa	23	5	21.73	17	73.91	1	4.34
Posterior fossa	43	3	6.97	33	76.74	7	16.27
Comminuted fractures	51	12	23.52	36	70.58	3	5.88

* The excess of direct injuries of the brain with fractures of the front of the cranium suggests that some of the heads were injured after the victims had been knocked down.

TABLE 3.—*Distribution of Bruises of the Brain with Two Hundred and Nineteen Fractured Craniums*

Regions of the Brain	Location of Fracture									
	Vault		Anterior Fossa		Middle Fossa		Posterior Fossa		Comminuted	
	No.	%	No.	%	No.	%	No.	%	No.	%
Frontal	40*	54.05	14	60.87	9	33.33	33	75.0	28	54.90
Temporal	51	68.91	8	34.70	18	66.67	30	68.18	34	66.67
Parietal	8	10.81	2	8.69	0	0.0	2	4.55	12	23.52
Occipital	7	9.46	3	13.04	3	11.11	1	2.20	0	0.0
Cerebellum	9	12.16	0	0.0	7	25.97	8	18.18	11	21.56
Pons	6	8.11	0	0.0	2	7.41	5	11.36	4	7.84

* The numbers indicate bodies. It should be understood that the bruises were often multiple in many of the places, for example, 40 under frontal lobes means that there were bruises so located in the brains of forty bodies.

there was contrecoup bruising of the cortex of the left temporal lobe, and apparently death was due to these injuries alone. Nippe [1] reported the similar death of a young woman who was found sitting in the front seat of an automobile; violence had been applied to the chin, and death had resulted from contrecoup bruising of the brain.

In dealing with the extent of the injuries of the brain, a classification employed elsewhere [2] will be followed. Petechial hemorrhages and

1. Nippe, M.: Ueber eine typische Kraftwagenverletzung, Hirnrinden-Kontusion und intermeningeale Blutungen ohne Verletzung des Schädelknochens und ohne Weichteilverletzung im Bereich des Gehirnschädels, Deutsche Ztschr. f. d. ges. gerichtl. Med. **9**:34, 1927.

2. LeCount, E. R., and Apfelbach, C. W.: Pathologic Anatomy of Traumatic Fractures of Cranial Bones and Concomitant Brain Injuries, J. A. M. A. **74**:501 (Feb. 21) 1920.

contusions of the cortex (the fourth class), with the simple linear fractures, were present in seventy-one bodies (42.26 per cent), eighteen (35.29 per cent) of which had extensive comminuted fractures. Some intraleptomeningeal and subpial hemorrhage was present in 93 per cent of the 224 bodies, and was usually generalized over the entire brain in varying amounts.

Lacerations from 2 to 4 cm. long and from 1 to 2 cm. deep, frequently associated with torn leptomeninges, occurred in fifty-one (30.35 per cent) of the bodies with simple linear fractures and in twelve (23.52 per cent) with comminuted fractures. In about half of these, the meninges were extensively lacerated, as was the dura, and in three there was herniation of the brain. Minute hemorrhages into the pons, intracerebral hemorrhage about the basal ganglions and intracerebral hemorrhage associated with marked extradural bleeding were much less common and were found in forty-one bodies (18.67 per cent). Of these, the multiple hemorrhages in the pons, a few millimeters in diameter, were the most common. Tears or bruises from a few millimeters to 15 in length and depth (the third class) were present in forty bodies (23.80 per cent) with simple branching and in sixteen (31.37 per cent) with comminuted fractures. The injuries to the brain of the first class, lacerations from 4 to 6 cm. in diameter and from 4 to 5 cm. in depth, were more frequent with the extensively comminuted fractures of the cranial bones and were found accompanying fourteen of the fifty-one (27.45 per cent) and only nineteen of the 168 (11.30 per cent) simple linear fractures.

Extradural and Subdural Hemorrhage.—In the eighteen bodies showing fractures in the bones of the anterior fossa, some extradural bleeding was encountered in four (22.22 per cent); in thirty of the seventy-three with fractures of the vault (41.09 per cent); in five of twenty-three with fractures of the middle fossa (21.73 per cent); in thirteen of forty-three with fractures of the posterior fossa (30.23 per cent), and in nine of the fifty-one with unclassifiable comminuted fractures (17.64 per cent). This is a total of sixty-one fractured craniums with some extradural hemorrhage, and in about half of these (thirty-one) there was compression of the underlying part of the brain. The average weight of these blood clots was between 35 and 65 Gm.; a number were several times heavier.

Subdural hemorrhage was found in ninety-seven bodies (43.49 per cent) with fractured craniums and in twenty-one (41.17 per cent) of the fifty-one with comminuted craniums, associated in five with direct bruises and in sixteen with contrecoup bruises. It was present in eight (two with direct bruising) of the eighteen cases of fracture of the anterior fossae (44.44 per cent); in forty-one of the seventy-three cases

of fracture of the vault (56.16 per cent); in twenty of the forty-three of fractures of the posterior fossa (46.51 per cent), and in seven of the twenty-three of fractures of the middle fossae (30.43 per cent). The weight of the blood varied from a few to 150 Gm., the average being 52 Gm.

Hemorrhage Into the Accessory Nasal Sinuses.—Hemorrhage into one or more of the nasal cavities was noted in forty-nine bodies (22.27 per cent). If bleeding occurred in only one of the sinuses, it was usually the ethmoid; blood in the sphenoid and frontal sinuses was less common. It is not uncommon to have two sinuses affected, usually the ethmoid and sphenoid, or the frontal and ethmoid. The presence of blood was uncommon in the middle ears. The internal ears were not examined with any regularity.

Traumatic Edema of the Brain.—Traumatic edema was present in some measure in almost all of the brains with broken skull bones; in five it was the only change in the brain. Pressure furrows of the brain stem or cerebellum were noted in 14.91 per cent of the brains and internal hydrocephalus in 13.37 per cent.

Symptoms.—The majority of the patients were in a state of shock at the time of admission. For those who lived only a short time, the clinical records were necessarily meager. The pulse was imperceptible, rapid or weak, the rate being as slow as 11 in one patient and as frequent as 140 per minute in others. Respirations were slightly more rapid than normal, from 22 to 36; Cheyne-Stokes respiration was present in a few and stertorous breathing in some. In many the temperature at the time of entrance was subnormal; the lowest was 92 F., the average being 97 F. The temperatures of from 101 to 108 F., observed in thirty-two, were due to infections or sudden terminal rises. The blood pressure for forty patients (21.39 per cent) was recorded. In one there was a hypertension of 270 mm. of mercury systolic pressure, and 140 diastolic, and albumin and casts were present in the urine; contracted kidneys were found post mortem. In four there was hypotension of from 95 to 110 mm. of mercury systolic pressure. In the remaining thirty-five the average systolic pressure was 144 mm. and the diastolic 84.

Sugar is frequently found in the urine of patients with broken cranial bones resulting from injuries of the base of the brain about the floor of the third ventricle. In this series, it was recorded only once; presumably it was not commonly sought.

Hemorrhages from the ears, nose and mouth occurred in 115 (61.49 per cent), vomiting of swallowed blood in twelve, convulsions in two, hemiplegia in two and facial paralysis in three; the presence of dilated pupils was frequently recorded.

Spinal Fluid.—The spinal fluid was examined in ninety-two (68.65 per cent) patients in whom a diagnosis of fracture of the skull or "suspect skull fracture" had been made. In forty-four (47.82 per cent), it was bloody. In one this was demonstrable only with the microscope, and in two almost pure blood was obtained. In thirty-nine (42.39 per cent), the fluid was bloody and under increased pressure. In two (2.17 per cent), it was normal; of six (6.52 per cent) patients with traumatic meningitis, it was cloudy in four, in one of whom there were 25,000 white blood cells per cubic millimeter, mostly polymorphonuclear leukocytes and gram-positive intracellular diplococci. In two the spinal fluid was turbid and under increased tension, with 18,000 white blood cells in one and 3,000 in the other; in the latter, the results of the Noguchi and Ross-Jones tests were positive.

Diagnosis.—Of the 187 patients under observation in the hospital, diagnosis of fracture of the skull was made for 110 (58.82 per cent) and of "suspected skull fracture" in twenty-four (12.83 per cent); in the remaining fifty-three, fractures of the extremities and ribs were recognized for the most part, and the broken cranial bones were overlooked; alcoholic coma was present in two; epidemic meningitis was diagnosed in three patients admitted to the hospital eighteen days, twenty days and six months after the accident, respectively. In seven, a clinical diagnosis was not made.

Decompression Operations.—In eleven patients, two with comminuted broken cranial bones, decompression was performed. In one of those with broken cranial bones there was both extradural and subdural hemorrhage; death occurred one day later. In the other, the dura was extensively lacerated and the superior sagittal sinus torn open; death occurred on the operating table.

Decompression was performed on one patient with fracture of the vault in which both extradural and subdural hemorrhage was present; at the postmortem examination five days later, an abscess of the right frontal lobe was found. In the remaining eight, basal skull fractures, with an extradural clot were present in four, in one of whom there was marked compression of the brain; in another, a subdural clot was present; in another, marked hemorrhage into the leptomeninges and lacerated dura with herniation of a portion of the brain was found; in the remaining two, subdural hemorrhage with a slight amount of extradural bleeding was found.

Meningitis.—Of the nineteen (8.48 per cent) persons developing meningitis there were four boys, aged from 6 to 8 years, two women and thirteen men. Death occurred from two days to six months after injury; in one, the time of the injury could not be ascertained. This person refused to stay in the hospital, but reentered one day before

death in a semicomatose condition with evidence of meningitis. A branching linear fracture of the frontal bone, 10.5 cm. in length, was found post mortem. The brain was edematous, and there was a slight subdural hemorrhage on the left side of the brain, with pyocephalus and an acute fibrinopurulent leptomeningitis.

In all of the cases of meningitis, the condition was fibrinopurulent, with the exudate more fluid in some bodies than in others. In one body there was thrombophlebitis of all the sinuses of the dura with a meningitis; infection occurred from the ethmoid sinuses through a fracture which crossed from one side to the other. The meningitis was always generalized, except in one body, in which it was present about the right frontal lobe. The bones of the middle fossae were broken in fourteen bodies, the anterior fossae in two, the posterior fossae in two and in one there was no fracture of the skull. One patient had a serofibrinous pericarditis, pleuritis and peritonitis, with suppuration about a lacerated wound of the tissue near the left clavicle. A diagnosis of septic arthritis with a streptococcal septicemia had been made one day before death. At necropsy, the bones of the front of the cranium were found broken. Another patient had a diffuse fibrinous leptomeningitis, pleuritis and pericarditis, a beginning hypostatic bronchopneumonia and a fracture through the floor of the right middle fossa. Two of the patients received antimeningococcus serum, 25 and 30 cc., respectively; in two others, decompression was done.

The death of a boy, aged 6, who was run over by a truck, occurred thirty-three days after the accident from serofibrinous peritonitis, pleuritis, pericarditis and leptomeningitis. There were chronic suppurating lacerated wounds of the lower part of the abdomen and of the left thigh and leg. Pure cultures of hemolytic streptococci were obtained from the pleural effusion, the heart's blood and the pericardial and cerebrospinal fluids. When the patient entered the hospital, a fracture of the skull was suspected; none was found at necropsy. The important details of the injuries in a few other bodies illustrate various types of accidents and their results.

Broken Cranial Bones with Extensive Injury to the Brain.

Case 1.—A woman, aged 39, was struck by a motor truck and at the time of admission was stuporous, bleeding from the right ear and vomiting bloody material. The diagnosis of basal skull fracture was made; death occurred nine days later. At the postmortem examination a fracture of the posterior fossae, 27 cm. in length, with a small amount of extradural hemorrhage (8 Gm.), was found. Over the right middle temporal gyrus the leptomeninges had been torn away, and the brain tissue beneath was lacerated outside for 7.5 by 1.5 cm., and 6 mm. into the brain substance. Superficial contrecoup bruises of both frontal lobes were present. Externally, a contusion was still evident behind the right ear.

Case 2.—A man, aged 45, had fallen from a truck and struck his head on the pavement; he was admitted to the hospital in coma; death occurred twenty-one

hours later. Necropsy revealed: a fracture of the posterior fossae, 21.1 cm. in length, and a diastasis of the sagittal suture; contrecoup bruises and lacerations of the under surfaces of both frontal and temporal lobes, from 1 to 2.6 cm. in diameter, and extending through the gray cortex and from 2 to 3 mm. into the white substance of the brain; minute hemorrhages in the pons, and slight extradural and subdural bleeding about the cerebrum. The only external marks of violence were abrasions of the head and back.

CASE 3.—A boy, aged 13, was admitted to the hospital in a state of coma after an automobile accident; there was bleeding from the nose; he died at the end of fifteen hours. Necropsy revealed: a branching fracture, 22.5 cm. in length, through the squamous part of the left temporal bone, with a slight amount of subdural and intrameningeal hemorrhage; marked edema of the brain; blood in the lateral ventricles; hemorrhage in the right lenticular nucleus (14 by 12 mm.), in the corpus callosum (20 by 6 mm.), in the right dentate nucleus (1 by 1 cm.) and in the medulla (7 by 2 mm.).

Extensive Extradural Meningeal Hemorrhage.

CASE 4.—A man, aged 55, was in an automobile accident. At the hospital a diagnosis of a dislocated right clavicle and acute alcoholism was made. Death occurred seventeen hours after he was admitted to the hospital. Necropsy revealed: a fracture, 14 cm. in length, through the right petrous bone; the right frontal lobe depressed by an extradural clot weighing 190 Gm.; intraleptomeningeal hemorrhage on the two sides of the brain, and superficial contrecoup bruises of the left frontal and occipital lobes, 2 cm. in diameter. The second to the sixth ribs were broken on the right side, and also the right clavicle. There were small abrasions and contusions of the back of the head, the forehead and the right elbow; 11.62 cc. of alcohol was found in the stomach.

Comminuted Cranial Bones.

CASE 5.—A man, aged 50, after being injured by a taxicab, died en route to the hospital. Necropsy revealed: extensive comminuted fractures of all the cranial bones, most marked in the left anterior fossa and with all the sinuses opened; hemorrhage in the leptomeninges over the entire brain; the dura over the left temporal lobe extensively lacerated; the olfactory bulb and tracts torn away; the optic chiasma and pons markedly torn; the medulla separated from the pons; superficial contrecoup bruises of the right frontal and temporal lobes; fractures of the second to the ninth ribs on the left and of the second and third ribs on the right, with the upper lobe of the left lung lacerated. There were cuts of the nose, the eyelids and the right leg, and abrasions of the cheeks.

Other Types of Cases.

CASE 6.—A boy, aged 14, entered the hospital with typical symptoms of a basal skull fracture. He seemed to be getting along very well until the seventh day, when he died unexpectedly. The skull was fractured for 19.5 cm. in the middle fossae. There were contrecoup bruises of the under surface and in the cortex of both temporal lobes, 3 by 0.3 cm. in the right side and 1 by 0.2 cm. in the left. Abrasions were present on the right side of the head, face, shoulder and thigh, with extradural hemorrhage.

CASE 7.—A woman, aged 52, was thrown through the top of an automobile when it overturned; she struck the pavement and became unconscious at once. At the time of admission, she vomited bloody material. A diagnosis was made of fracture of the skull and broken right clavicle; death occurred ten days later. The postmortem examination revealed a partly healed fracture, 8.4 cm. in length,

of the right anterior fossa; a slight amount of subdural bleeding over the left parietal lobe; a contusion and laceration in the left inferior temporal gyrus, 2 cm. in diameter and 5 mm. deep; marked edema of the brain, and hypostatic hyperemia and edema of the right lung. The right clavicle was fractured, as were also the second to the fourth ribs of the right side. There were healing abrasions of the right arm and hand.

Case 8.—A man, aged 68, who was injured by an automobile, entered the hospital in a state of stupor. A diagnosis was made of fracture of the skull; death occurred twenty-one hours later. Necropsy revealed: a fracture, 25.2 cm. in length of the left parietal and frontal bones including the roof of the right orbit; a small subdural (10 Gm.) and extradural hemorrhage with an extensive subpial hemorrhage. The under surface of the right temporal lobe was lacerated and contused for an area 4 by 2 cm. and from 3 to 5 mm. deep. At the tip of the right frontal lobe, a small superficial bruise was found; bronchopneumonia and abrasions of the left side of the head and elbow were present.

Case 9.—A man, aged 45, whose wagon was struck by a truck, was thrown onto the pavement. A diagnosis of fracture of the skull was made; death occurred after eleven days. Necropsy revealed: fracture of the posterior fossa, subpial hemorrhage over the frontal and right parietal lobes, superficial contrecoup bruises of both frontal lobes and a slight foramen magnum pressure furrow of the brain stem, marked edema of the entire brain and thrombosis of the left lateral dural sinus. The third to the tenth ribs of the left side were broken near the vertebral column, and one of the jagged ends made by the fracture of the seventh rib had punctured the lower lobe of the left lung, the hole in the lung being 10 by 15 mm. There was pneumonia of the lower lobe of the left lung. The only mark of external violence was a contusion of the back of the head.

Case 10.—A woman, aged 40, was admitted to the hospital after being struck by an automobile. She was in coma and was bleeding from the nose and ears. A diagnosis of basal skull fracture was made. Before death eight days later, leptomeningitis was demonstrated. Necropsy revealed: a fracture with a total length of 42.5 cm. from side to side across the front part of the middle fossae, also involving the ethmoid bone (this is referred to in the discussion of meningitis), and a broken mandible; fibrinopurulent leptomeningitis of the right side of the brain, septic thrombosis of all the dural sinuses, extradural and subdural clots with a moderate amount of compression. There were superficial bruises of the right frontal and temporal lobes and one hemorrhage, 3.5 by 0.3 cm. in diameter, involving the gray and white matter. Abrasions of the right cheek and contusions of the left thigh were the only external injuries.

Injuries Solely of the Cranium.—With the exception of a laceration of the upper pole of one kidney in one body, the injuries in eighty-four (37.66 per cent) of the 223 bodies with fractured cranial bones were solely of the head: broken cranial bones, traumatic diastases and injuries of the brain. In this group nine deaths occurred while the patients were en route to the hospital, thirty-seven, from one-half to twenty-one hours after admission to the hospital and thirty-seven after from one to twenty-two days; for one, the time of death was not learned. The death which occurred twenty-two days after the accident resulted from intercurrent ascending infection of the urinary organs; four patients

developed a marked bronchopneumonia; one, thrombosis of a transverse sinus of the dura, and another abscess of one lung.

Injuries of Craniums and Other Parts of the Body.—In eighty-eight (39.46 per cent) of the 223 bodies there were fractured bones (table 4) other than cranial. The associated injuries of the viscera are shown in table 5. Eleven of this group of eighty-eight persons died en route to the hospital, forty-one from one-half to eighteen hours after admission and thirty-three after from one to seventeen days. For three, the time of death was not learned. Meningitis occurred in five, hypostatic

TABLE 4.—*Fractures of Other Bones with Simple Cranial Fractures in Eighty-Eight Bodies* *

Ribs	50
Vertebrae	18
Pelvic bones	11
Tibia	8
Fibula	7
Humerus	7
Femur	5
Radius	1
Ulna	1
Scapula	1

* These 88 bodies were 51.16 per cent of all the 172 with such fractures. In the remainder (84) the craniums alone were broken.

TABLE 5.—*Visceral Injuries with Linear Fractures* in *Eighty-Nine Craniums* *

Lungs	19
Liver	8
Spleen	7
Kidneys	4
Suprarenal glands	3
Torn mesentery	1
Contused heart	1
Torn urinary bladder	1
Torn right subclavian vein	1
Torn common carotid artery	1

* With eighty-eight of these (table 4) other bones were broken; with one, the other injuries were bruises of the brain and a torn kidney.

bronchopneumonia in three, marked hypostatic hyperemia and edema of the lungs in two, thrombosis of the dural sinuses in one, intercurrent cystitis and endocarditis in one, serofibrinous pericarditis, pleuritis and peritonitis and leptomeningitis with lobar pneumonia in one and abscess of the brain in one.

Extensively Comminuted Cranial Bones.—Of the fifty-one bodies, the injuries were confined entirely to the head in twelve. In the remaining thirty-nine, the other fractures are indicated in table 6 and injuries of the viscera in table 7. Sixteen died en route, nineteen from one to sixteen hours after entrance, and sixteen from one to fifteen days later. Among the sixteen, death resulted from lobar pneumonia in one, gangrene of the lung in another, and complete severance of the spinal

cord at the level of the sixth cervical vertebra in a third. The terminal infections developed from one to fifteen days after the accident.

External Injuries of the Head and Body.—In ninety-six bodies, the violence occurred to the right side of the head, in sixty-four to the left side, to the back in forty-two and to the front in twenty-two. Hemorrhage in the deep tissue of the scalp was always found at the site of violence, and in six this was the only indication of violence; in the

TABLE 6.—*Other Bones Broken in the Fifty-One Bodies with Extensively Comminuted Craniums* *

Ribs	35
Fibula	11
Tibia	10
Clavicle	6
Pelvic bones	6
Femur	2
Patella	1
Sternum	1
Humerus	1

* Although the craniums were severely injured, the fractures elsewhere are actually fewer than in bodies with simple linear cranial fractures.

TABLE 7.—*Visceral Injuries Associated with the Fifty-One Comminuted Craniums* *

Lungs	10
Liver	6
Torn bowel	4
Kidney	3
Spleen	2
Contused pancreas	2
Contused esophagus and stomach	1
Torn aorta	1

* The visceral injuries are more frequent with comminuted than with linear branching fractures.

TABLE 8.—*Broken Bones in Three Hundred and Sixty Bodies* *

Cranial and facial bones	224	(58.58%)
Ribs	169	(44.12%)
Extremities	107	(27.93%)
Spine fractures and dislocations	60	(15.66%)
Pelvic bones	42	(10.90%)

* In twenty-three bodies there were no bones broken.

others, there were external lacerations and bruises. In eleven of the 224 bodies showing fractures of the skull, the external injuries of the head were the only marks of violence on the body. The types of injury of the scalp are shown in table 9. The forehead, lips and cheeks were the most frequent sites for the injuries of the face.

In 212 (95.06 per cent) of the bodies, the injuries of the head were associated with other marks of external violence. In eighty-nine (41.93 per cent), the lesions of the body were on the same side as those of the head; in 113 (53.30 per cent), the lesions were on both sides of the

body, but usually with a predominance of injuries on the same side as those of the head. In ten (4.72 per cent), there were several abrasions of the body on the side opposite the injuries of the head. The most common places for the lacerations were the elbows, hands and fingers and the knees and lower third of the legs; the penis was extensively lacerated in two bodies. Bruises associated with abrasions were the most common; bruises with lacerations were relatively infrequent and occurred in about one fifth of the 212 bodies.

FRACTURES AND DISLOCATIONS OF THE VERTEBRAE

The cervical part of the spine was injured in twenty-six bodies (6.79 per cent), the thoracic in twenty-three (6.01 per cent) and the lumbar in eleven (2.09 per cent). In ten of the sixty bodies, the only bony structure injured was the spine. The injuries of the cord and

TABLE 9.—*Injuries of the Head in Two Hundred and Twenty-Four Bodies with Fractures of the Skull* *

Types of Injuries of the Face and Scalp	Bodies
Lacerations	173
Abrasions	139
Contusions	142
Injuries of the Scalp Alone	
Contusions, abrasions, lacerations	45
Lacerations	43
Contusions, abrasions	39
Contusions, lacerations	28
Abrasions	28
Contusions	10

* Information was deficient concerning the injuries of the brain in four bodies, but details of the fractures and injuries of the scalp for these four were complete. In twenty-five others, the external injuries were limited to the face. In many bodies, the contusions of the scalp were not evident externally.

their sequences caused the death of three of the ten; bronchopneumonia caused death in three others; one lung and the suprarenal gland of the same side were both torn in another, and in one the liver and one kidney were lacerated. In the other fifty bodies with injured spines, there were also fractures of various bones: broken ribs in twenty-eight, fractures of the cranial bones in eighteen, of the bones of the extremities in sixteen and of the pelvic bones in five.

Cervical Vertebrae.—The injuries to the cervical vertebrae of the spine were chiefly in the caudad half. In only one of the twenty-six was the atlas broken and with this there was a basal cranial fracture. In four bodies the only vertebra broken was the epistropheus, in three the seventh vertebra, and in four bodies the fourth, fifth and sixth alone. The dislocations were between the fifth and sixth vertebrae in two bodies, between the sixth and seventh in three, and in one body there were simply fractures of the transverse processes of the fifth and seventh vertebrae. With the dislocations, the overhanging lip of the ventral surface of the upper vertebra was often splintered away some-

what from the rest of the body, and with all the injuries of the cervical part of the spine there was hemorrhage in the scaleni muscles and other soft structures close to the bones, which was exposed when the organs and other structures of the neck were removed.[3]

In two patients, a fractured fourth cervical vertebra (one comminuted) was the only bone injured. For each a diagnosis of fracture of the skull was made, and for one, fracture of a cervical vertebra also. One of these bodies had abrasions of the back over the spine; the other had only a laceration of the left side of the head. In both a great deal of blood was present in the leptomeninges about the fracture, and in the one with the vertebra comminuted, there was blood about all the cervical and the first three thoracic vertebrae.

In another body, the fractured second cervical vertebra was the only injury of the bone. This was diagnosed as fracture of the skull. The spinal cord was "pulpy" at this level from contusion, and blood was found in the spinal canal. There was no mark of external violence anywhere on the back. One patient had a dislocation between the seventh cervical and the first thoracic vertebra; death occurred five days later from bronchopneumonia; paralysis was complete below the arms; a diagnosis of fractured spine was made.

Thoracic Vertebrae.—The thoracic portion of the spine was injured in twenty-three bodies. The ninth thoracic vertebra was broken most often (five bodies), the ninth thoracic vertebra with the eleventh in one, and with the tenth in another. The first was the only vertebra fractured in one body as were also the third, fifth, eighth, tenth, eleventh and twelfth in six others. The second and third were injured in one, the fifth and tenth in another, the seventh and eighth in a third, the eleventh and twelfth in a fourth, the fourth in two bodies and the seventh in two others; the seventh cervical was separated from the first thoracic vertebra in one.

Lumbar Vertebrae.—The lumbar vertebrae were injured in eleven bodies. The body of the first lumbar vertebra was fractured in seven, the transverse processes of the first three in three, and the body of the fifth in one.

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3. Fracture-dislocations of the neck may be made after death by careless handling of the body. A single orderly, with no one to aid him at the other end, flips the body by the head from the bed in the ward onto a cart, or in the morgue from a high to a low cart. Such postmortem injuries have considerable medicolegal importance because small veins about the dislocations distended with blood from hypostasis are torn and the blood from them escapes about the tears. But the amount of blood outside the vessels is always trivial and not spread deeply into torn and bruised tissues as is the case with antemortem fractures; the cord is uninjured.

PELVIC FRACTURES; INJURIES OF THE URINARY BLADDER

Fractures of the pelvic bones usually result from direct violence to the lower part of the trunk. Complete lacerations of the urinary bladder are often due to blunt force against the lower part of the abdomen; distention favors rupture. A spicule from a broken pubic bone may also tear the wall. In two of the fifteen bodies with fractured innominate bones, the bones were comminuted. In thirteen the innominate and other pelvic bones were broken; the fractures in the remaining fourteen are indicated in table 10.

Pelvic and Associated Fractures.—In three bodies, only pelvic bones were fractured: the right innominate in two, the left pubic and innominate bones and the ischium of both sides in a third. Death resulted not from these injuries alone but from a ruptured small bowel and hemorrhage into the mesentery in one patient, a marked secondary

TABLE 10.—*Fractured Pelvic Bones in Forty-Two Bodies* *

Innominate	15
Innominate, pubis, sacro-iliac diastasis	5
Innominate, pubis, symphysis pubis	2
Innominate, sacro-iliac diastasis	2
Innominate, ischium	1
Innominate, symphysis pubis	1
Innominate, ischium, pubis, symphysis pubis	1
All pelvic bones	1
Pubis (both)	6
Sacro-iliac diastasis	2
Sacrum	2
Coccyx	1
Symphysis pubis, right sacro-iliac diastasis	1
Pubis, symphysis pubis, coccyx, sacro-iliac diastasis	1
Pubis, ischium	1

* Of the forty-two bodies, twenty-eight (66.67 per cent) had broken innominate bones. In about half of the twenty-eight, other pelvic bones were also broken.

anemia from multiple lacerations of the lower extremities in one and from bronchopneumonia with one small abscess of the lung in the third.

In the remaining thirty-nine bodies, there were associated broken cranial bones in fifteen; ribs in twenty-one; one clavicle in six; the spine in five; one tibia and fibula in four; one femur in three; one humerus in three; one tibia in two; the sternum in one body, and one radius in another. In one body, the only injury to the pelvic bones was a diastasis of the left sacro-iliac synchondrosis; the left tibia and fibula, the spine between the fourth and the fifth thoracic vertebrae, the third rib on the left and the third to the seventh on the right side were also all broken; the right frontal cerebral lobe was bruised. This was the body of a woman, aged 58, who died four days after admission to the hospital. In four bodies, fractured ribs caused injuries of the lung and pleura. Other causes of death were lobar pneumonia with beginning bronchopneumonia and torn bowel, each in one body. The injuries of the head, fractured skulls and contused brains, were probably the chief causes of death of about one third of the forty-two persons with broken pelvic bones.

Lacerated Urinary Bladder.—In three bodies there was laceration of the urinary bladder all the way through its wall, and in one partly through. The fractures of the bony pelvis were a little different with each of these bodies: symphysis pubis and right sacro-iliac synchondrosis, one; symphysis, right innominate and both pubic bones, one; right innominate, both pubic bones and both sacro-iliac synchondroses, one, and both innominate bones alone with the incomplete laceration. All the wounds of the bladder were in its ventral wall, extraperitoneally; they were transversely directed and were from 7 to 9 cm. in length. Fluid and clotted blood were found in each of the four bladders. Death occurred at the end of from two to twenty-two hours after the accidents; peritonitis was not found in any of the four bodies.

BROKEN RIBS AND TORN LUNGS

Fractured Ribs.—In thirty of the 169 bodies with broken ribs, these were the only fractures. In eighty-five, the fractured ribs were associated with broken cranial bones, in twenty-eight with fractures of the vertebral bodies or transverse processes, in twenty-one with broken pelvic bones and in sixty-three with fractures of the extremities. In ninety-nine (58.05 per cent) of the 169 there were broken ribs on only one side, in fifty-five on the right and in forty-four on the left. When the ribs were broken on both sides, as they were in the remaining seventy-two bodies, as a rule, more were broken on the right side.

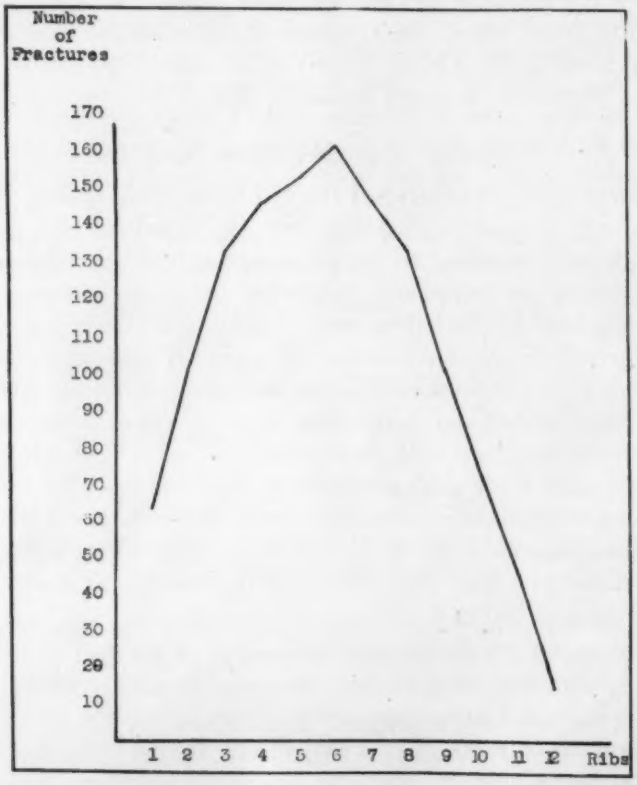
In 169 bodies there were altogether 1,271 fractured ribs. The number of times the various ribs were broken is shown in the accompanying chart. The incidence is in accord with that reported by Riedinger,[4] who found that the fifth and sixth ribs were fractured most frequently and the first and twelfth least often.

Lacerations of the Lungs.—In fifty-eight of the 169 bodies (34.32 per cent), there were tears in the lungs opposite the fractures. In four of the fifty-eight, the torn lungs also had deep lacerations with only subpleural bleeding to mark their location. In fifteen other bodies there were either lacerations or superficial bruises of the lungs, but the ribs had remained unbroken; in ten of the fifteen there were simply bruises of the outside of one or both lungs. This is a total of seventy-three (19.07 per cent) bodies in which injuries of the lungs occurred. In those with the ribs intact, the sternum was broken in one at the level of the second costal cartilage; in three others one clavicle was injured. In eleven the lung was injured without damage to the ribs, clavicle or sternum; in three of the eleven there was simply subpleural bleeding and in the others, tears involving the outside of the lungs. Bruises of the muscles of the wall of the chest at the point of external violence were found

4. Riedinger, J. F.: Chirurgische Krankheiten des Thorax, Deutsche Chir., 1888, vol. 42.

in two of the eleven, and there were abrasions and contusions of the chest in the others.

Subcutaneous Traumatic Emphysema.—Subcutaneous emphysema is often a sign of fractured ribs and occurs usually about the site of violence; occasionally it spreads over the entire body. It was localized about broken ribs in six bodies and extended from the lungs to the mediastinal tissues in only one body.



The incidence of fractured ribs. In 169 bodies, 1,271 ribs were broken. The only irregularities of the curve concern the fractures of the third and seventh ribs. In many bodies some of the ribs were broken more than once, but in the estimate of the 1,271 fractures used in the graph, multiple fractures in a single rib have been counted as only one. The peak of the curve is, at least, 161 fractures in the sixth ribs, 161 of the total of 1,271, or 12.66 per cent.

Extent and Location of the Tears in the Lungs.—Many of the lacerations were from 8 to 11 cm. long and from 2 to 7 mm. deep. In two bodies, the tear almost bisected a lobe. In seven, the lacerations were in both lungs. The lungs were compressed by the blood about them, and from tears alone in seven bodies. The blood in the pleural cavities

was usually weighed. Sixty-six such estimates were made, a single side of the thorax being counted for each. The average weight was 50 Gm., the greatest 310 Gm. Fibrous adhesions hindered the accumulation of blood about some lungs.

Traumatic Pneumothorax.—Traumatic pneumothorax was present in eight bodies, five those of children from 5 to 8 years of age and the others, adults from 24 to 32 years. In three bodies the pneumothorax was bilateral, in three others of the right side only and in the other two of the left. In six of the eight bodies, spicules of broken ribs had pierced the lungs deeply. In one of the bodies the following unusual conditions were found:

CASE 11.—A boy, aged 7 years, had a tear, 5 cm. in length, deep in the interlobar fissure between the lobes of the left lung; the tear gaped widely. Another similar laceration occurred at the bottom of the chief interlobar fissure of the right lung, and there a good-sized bronchus was torn through completely. Both lungs were mottled outside with exceedingly pale areas as a result of air under the pleura without its normal channels; such pale spots alternated with other dark red spots which resulted from hemorrhage. The diaphragm was pushed down by air in the pleural cavities, which escaped with a gush when the cavities were opened. There was a small tear of the dorsal margin of the left lobe of the liver; there was not a bone broken anywhere in the body. Death ensued while the patient was en route to the hospital.

TABLE 11.—*Torn and Bruised Viscera in One Hundred and Fifty-Nine Bodies* *

Lung	73	(19.07%)
Liver	53	(13.83%)
Spleen	25	(6.52%)
Kidney	25	(6.52%)
Suprarenal gland	18	(4.65%)
Ileum	6	(1.57%)
Heart	6	(1.57%)
Pancreas	4	(1.04%)
Mesentery	4	(1.04%)
Jejunum	3	(0.78%)
Esophagus	2	(0.52%)
Stomach	2	(0.52%)
Duodenum	1	(0.25%)

* This makes an average of 1.39 injured viscera for each day.

Pneumothorax was usually demonstrated by holding the reflected soft parts of the chest up against the inner parts of the unopened wall of the thorax so as to make a cup, most of the circumference of which was formed by the reflected parts. Water was poured into this cup and the thorax opened under water. This was not always done, for if it had been done more regularly and more carefully, pneumothorax, especially with small quantities of air about the lungs, would probably be more common in the records.

Cause of Death.—In five bodies with torn lungs, the injuries of the thorax contributed little to the cause of death. Considerable clotting of the blood in the cavity about the injury of the lungs had occurred.

In one of the five, there was a small abscess in the lower lobe of the left lung; in the other four cranial bones were broken and the brain was injured.

In a man, aged 45, lobar pneumonia was the cause of death eleven days after the accident. It developed where the laceration had occurred in the lower lobe of the left lung. There was also thrombosis of the left lateral dural sinus with some broken cranial bones. Extensive bronchopneumonia of the lower lobe of the left lung was found in another body with fractures of the fourth to the tenth ribs of the right side; a tear of the pleura on the right side and a compound fracture of the right tibia and fibula were also present.

FRACTURES OF THE EXTREMITIES

Fractures of the extremities occurred alone in twenty-one bodies, were accompanied by broken cranial bones in sixty-two, by broken ribs in sixty-three, and by broken pelvic bones in eighteen. With the fractures limited to one or more extremities, death usually resulted from intercurrent infections, mainly bronchopneumonia. Hypostatic hypermia and edema of the lungs were often found. A marked edema of the brain with concomitant lacerations and abrasions of the scalp were present in two, and in one body with broken bones in the extremities the right ventricle of the heart was torn open.

In twenty-eight cases (fourteen of each side) the femur was broken, and in three elderly persons the bones at the neck. Subcutaneous fractures of the tibia and fibula on one side were found in twenty-five bodies, and compound fractures of these bones in nine. These fractures were on the left side in eighteen bodies and on the right in sixteen. The tibia was fractured without the fibula in six (right side two, left side four) and one fibula alone (each side two) in four; in one body the right patella and in another the bones of the left ankle were broken.

The humerus was fractured twenty-four times (right thirteen, left eleven), only once at the neck; in seven bodies one radius was injured (right side four, left three); in three bodies the right ulna was broken and with each the corresponding radius was broken. The bones of the lower extremities were more frequently broken than those of the upper; seventy-four of the lower extremity to thirty-four of the upper, a ratio of 2.17:1. The femur and fibula were broken the same number of times on both the right and the left sides, and the tibia and fibula together and the tibia alone were involved more frequently on the left side.

TRAUMATIC RUPTURE OF THE HEART

Ruptures and contusions of the heart were found in the bodies of five men and in that of a boy, aged 8 years. In each the heart was otherwise healthy. There were extensive comminuted fractures of the

cranial bones in two of the six bodies, a simple linear fracture in a third, broken ribs in five, and in one a fracture of the sternum. There were lacerations of the anterior surfaces of the lungs in each of the five with fractured ribs, tears of the liver in four (table 16), of one kidney in two, one suprarenal gland in one, and a bruise of the pancreas in one body.

The violence was applied directly to the wall of the chest of all six bodies, breaking the ribs in five, the sternum in the sixth and tearing one lung in all but one. Violence was also applied to the head of three and resulted in broken cranial bones. Only the upper and lower extremities escaped serious injury, but they bore abrasions and contusions. In the body in which the left auricle and ventricle were simply contused, the wall of the right side of the chest was markedly crushed, the cranial bones were extensively comminuted, and the first to the tenth ribs were broken on both sides; only a small amount (6 Gm.) of blood was present in the pericardial sac, but blood had infiltrated the mediastinal tissues, the sheaths of the large vessels and the suspensory ligaments of the liver. This man lived three and a half hours after reaching the hospital; the patients with perforating lacerations of the myocardium all died on the way.

The right ventricle was torn in four hearts, the right auricle in two (table 12). This differs somewhat from the statistics of Riedinger,[4] who found the right auricle always involved, the right ventricle next in frequency, then the left ventricle and lastly the left auricle. According to Rose and Carless,[5] the right ventricle is the part most often injured. Lacerations of the ventricle are less serious than those of the auricle because the musculature may check the bleeding in small tears of the myocardium.

The heart's action may cease at once, or be checked later by pressure from the blood in the pericardial sac. The blood in the sac in these six bodies weighed from 6 to 358 Gm. The sac was lacerated in three, and in one the tear was so small that it was kept closed by a blood clot. In another the heart was completely out of the pericardial sac through a huge tear, and the aorta was torn for 4 cm. at its root, the tear extending into the mouth of the left coronary artery. In one other body the aorta was lacerated completely across 2.5 cm. distal to the heart, and with this there were tears of the right auricle and ventricle. The lacerations were all in the front of the right auricle or ventricle, from 3 mm. to 3 cm. long, slitlike with even edges.

The liver was injured in four of the six bodies; this observation differs from those reported by Amante.[6] In his extensive tables of injuries

5. Carless, A.: Manual of Surgery (Rose and Carless), New York, William Wood & Company, 1924, p. 1050.

6. Amante, M.: Le lesioni traumatiche del fegato e delle vie biliari, Rome, 1912.

associated with ruptures of the liver, there is no mention of cardiac laceration in the 800 records of trauma of the liver. Many of the reports were of accidents before the days of motor vehicles, and many concerned falls from varying heights. The lacerations of the liver in the four bodies of our series were multiple; they were in both the right and the left lobes and on the concave surfaces in three. The right suprarenal gland was also extensively torn in one of the four bodies.

The extent and severity of injuries may be marked, as the following facts illustrate. A man, aged 30, was found dead on the street after having been injured by a truck. There were comminuted fractures in the cranial bones; the second to the tenth ribs inclusive were broken on the right side and the first to the tenth on the left; the fourth thoracic vertebra was fractured; the right leaf of the diaphragm was torn for 10 cm. near its back margin; the right auricle, ventricle, pericardial sac and aorta were lacerated; the concave surfaces of the right and left

TABLE 12.—*Injuries of the Heart in Six Bodies*

Perforating Lacerations	
Right ventricle	1
Right ventricle, pericardial sac	1
Right auricle	1
Right ventricle and auricle, aorta, pericardial sac	1
Right ventricle, oarta, pericardial sac	1
Simple Contusions without Rupture	
Left auricle and ventricle *	1

* With the bruised left ventricle and auricle, there were more external injuries of the front of the thorax than in any of the other five bodies.

lobes of the liver had multiple tears, and the posterior surface of the left kidney contained a small tear.

In another body in which the right auricle was torn open, there was also a tear across the right and half way across the left lobe of the liver. The right kidney was torn into two separate pieces, and blood from this injury contributed to the huge hemorrhage of 2,400 Gm. of blood in the abdominal cavity. With the contusions of the left side of the heart, there were also bruises of the stomach and pancreas.

TORN ARTERIES AND VEINS

In ten bodies (2.61 per cent), large arteries or veins were torn. The laceration of the abdominal part of the aorta observed in two bodies is especially interesting, because of the relative absence of other serious injuries, especially broken bones. One of these lacerations occurred in a man, aged 60, with abrasions and contusions of the abdomen to the right of the midline and just above the navel. The abdominal cavity contained about 1,300 Gm. of blood. The blood had oozed through from the loose tissues of the back wall of the abdomen where a huge hemorrhage had pushed these tissues ventrally on each side and from the

diaphragm to the brim of the bony pelvis. The blood had also spread from the root of the mesentery to its margin where the small bowel is attached. Most of the blood was about both kidneys, chiefly the right, and about the inferior vena cava and aorta. None had spread into the ventral wall of the abdomen.[7] The tear in the abdominal aorta was 2.5 cm. above its bifurcation through a region markedly calcified from senile sclerosis. The only other injury of this body was a lacerated tongue.

The other rupture of the abdominal aorta occurred in a man, aged 20. There were abrasions of the left elbow and leg, the chin and the back of the trunk. No bones were broken, but the great omentum and left kidney were torn. The tear in the aorta was completely across and just above the iliac vessels, and there was also a large retroperitoneal hemorrhage. The abdominal and thoracic aorta were free from disease.

Large Vessels of the Neck.—The large vessels of the neck were torn in five bodies: the right subclavian artery, the right deep jugular vein, the left internal carotid artery each in one body, and the left common carotid artery in two. In three of the bodies there were broken cranial bones; the vertebrae were fractured in three; the sternum in two; the right innominate bone in one; the clavicle in one, and in one body there was a laceration of the liver. One tear of the left internal carotid artery occurred in a man who was riding in an automobile which skidded, and he fell into a window, receiving lacerations of the top of the head, of the neck below the left ear, the nose, and abrasions of the face and neck. From the laceration below the left ear the blood spurted and a piece of glass, the size of a quarter, was removed; death occurred two hours after he was admitted to the hospital.

The torn right deep jugular vein was found in a body with the sternum fractured at the level of the third costal cartilage. With the torn right subclavian artery, the right clavicle and the second to the seventh ribs, inclusive of the right side, were broken. The tear in one of the left common carotid arteries was close to the aorta, associated with a fractured larynx and hemorrhage into the thyroid gland and right sternomastoid muscle; the other tear was small and played little part, if any, in the death which occurred from bronchopneumonia seven days later. The remaining laceration of a large artery occurred in the left femoral artery of a young man whose automobile collided with a street car; death ensued after two hours. There were abrasions and contusions

7. A fairly similar distribution of the blood in the loose tissues occurs with the rupture of aneurysms of the abdominal aorta or iliac arteries. The loose tissue of the dorsal wall of the abdomen may be pushed ventrally so far that when the abdomen is opened the retroperitoneal tissues are cut through with the same incision. Oozing into the urinary tract may occur and lead to a diagnosis of hypernephroma (E. R. LeCount).

of both thighs and legs, a broken right pubic bone with the front wall of the bladder exposed, a broken left femur and the fourth to the seventh ribs of the left side. The left femoral and superior gluteal arteries and saphenous vein had been lacerated extensively.

TORN ESOPHAGUS

In one body, that of a short-limbed dwarf, with fractures of many ribs on each side, of the transverse processes of the right second lumbar vertebra and a torn right psoas muscle, the esophagus was completely torn across through its middle, and again at the cardiac end. In another body there was a ventral longitudinal tear, 3 cm. in length, just below a fractured larynx; there were other severe injuries of the adjacent soft parts, fracture of the sternum and fracture of all of the ribs on the right side and of the first to the sixth ribs on the left side inclusive, with emphysema of the mediastinal and subcutaneous thoracic tissues.

RUPTURES AND CONTUSIONS OF THE DIAPHRAGM

Reports of ruptures of the diaphragm are rare, but it has been predicted [8] that they will become common with the great increase in, and the improved understanding of, accidents caused by motor vehicles. In adults such ruptures are often through the tendinous portion and from a broken rib. According to Hedri [9] the left side is more often torn, the proportion being 5:1. It is stated that the right side is protected by the liver. Actual rupture was found in eight of the 383 bodies (2.08 per cent). The right leaf was torn in five, and in each of the eight bodies there were multiple tears of the liver; herniation of the liver into the thorax occurred in one and bruises of the diaphragm in four others. The ruptures were commonly associated with many injured viscera, as shown in table 13, and in one account of rupture of the heart.

The tears and bruises of the diaphragm were associated with broken ribs in eight of the twelve bodies. Of the remaining four, the diaphragm was torn in two, but the ribs were intact; in the other two bodies, there were only bruises of the diaphragmatic muscle, but these were present on both sides. In two bodies there were broken cranial bones; in one, broken tibia and fibula of one leg with multiple fractures of the spine and a broken seventh thoracic vertebra and transverse processes of the first three lumbar vertebrae; in one, a comminuted left innominate bone, and in another a broken left clavicle and zygoma.

As stated, internal injuries are common with ruptures of the diaphragm. Of especial interest is the torn pregnant uterus found in

8. Hedri, A.: Beiträge zur Kenntnis der subkutanen Zwerchfellruptur, Med. Klin. **21**:736, 1925. Andersson, L.: Zur Kenntnis der Durch äussere Gewalt verursachten subkupanen Diaphragmrupturen, Beitr. z. klin. Chir. **135**:711, 1926.

9. Hedri (footnote 8, first reference).

the body of a woman with a torn diaphragm. Apparently, few such injuries are reported.[10] The laceration of the uterus was mainly on the right side, and was 22 cm. in length. The entire fetus, which weighed 735 Gm. and was 36 cm. long, was outside the uterus, with the exception of the left lower extremity. Moreover, part of the fetus had been projected through a tear in the mesentery of the distal part of the small bowel. The placenta was torn, and portions of it lay free in the abdomen. The liver was found partly in the thorax, projecting through a tear in the right leaf of the diaphragm. The right lung was also compressed by 563 Gm. of blood; that in the abdomen weighed

TABLE 13.—*Injuries of the Diaphragm and Associated Injuries Elsewhere in Twelve Bodies* *

Tears of the Right Leaf in Five Bodies	
Liver (right lobe in 3, left and right in 2)	5
Spleen	2
Hemothorax; compression atelectasis of lung	2
Herniation (liver in 1, stomach, greater omentum splenic flexure of colon in second)	2
Laceration of right lung	1
Laceration of trachea and bronchi	1
Heart	1
Torn pericardial sac	1
Left kidney	1
Right suprarenal gland	1
Left suprarenal gland (hemorrhage into medulla)	1
Ruptured gravid uterus	1
Torn mesentery, jejunum; bruised sigmoid	1
Bruised stomach and bowel	1
Tears of the Left Leaf in Three Bodies	
Liver (right lobe)	3
Hemothorax; compression atelectasis of lung	2
Herniation of stomach	2
Spleen	1
Hemorrhage into wall of urinary bladder (pelvic bones broken)	1
Bruises of Both Leaves in Four Bodies	
Liver	4
Lung	3
Suprarenal gland	3
Hemorrhage into fatty capsule of kidney	2

* It is of interest that with each tear or bruise of the diaphragm, there were associated tears of the liver.

693 Gm. Death occurred three minutes after the patient arrived at the hospital. The only bones broken were the left clavicle and the right zygomatic arch.

The tears were from 10 to 15 cm. long and near the ventral or dorsal margins, depending on where the ribs were broken. In four bodies there was herniation of the abdominal viscera or other structures into the thorax in whole or in part, compression of the lung and some hemothorax.

One man was found dead, another died en route; a third, with the diaphragm torn on the left side and the stomach in the left pleural cavity,

10. Frey, E.: Zur traumatischen Uterus Ruptur und der zweiten Hälfte der Schwangerschaft, Arch. f. Gynäk. **121**:92, 1923.

died at the end of twenty-one hours. The others died from one to four hours after admission, except the pregnant woman, who died soon after reaching the hospital.

LACERATIONS OF THE LIVER

Traumatic rupture of the liver is more common [11] than that of any other abdominal organ. The force may be applied directly to the region of the liver, or at some distance. In this series, the ruptures are common between the ages of 20 and 30 years (table 14) and also in the first and last decades. The numbers of bodies, however, are so few that conclusions about a greater frequency in any special period are not warranted.

Frequency of Lobes Injured.—Because of its great volume and exposed position, the right lobe was torn in forty-seven of the fifty-three bodies (88.69 per cent), the left lobe in ten (18.86 per cent), the quadrate in four (7.54 per cent) and the caudate lobe in two (5.66).

TABLE 14.—*Age Incidence of Injuries of the Liver in Fifty-Three Bodies*

Years	Bodies	Percentage
0 to 10	9	20.45
11 to 20	5	14.28
21 to 30*	11	28.20
31 to 40	9	13.63
41 to 50	10	15.15
51 to 60	3	5.45
61 to 70	3	6.12
71 to 80	1	6.66
81 to 90*	2	28.50

* The greatest percentage of injuries of the liver occurred in the third and last decades.

In one, the gallbladder with its wall intact was torn entirely away from its attachment to the liver. Lacerations of the quadrate and caudate lobes were rare and were always accompanied by injuries to other parts of the liver. In two bodies with tears of the quadrate lobe, there were lacerations of the right lobe; in another, with lacerations of both right and left lobes, and in a fourth all five lobes were torn. In the two bodies with torn caudate lobes, lacerations were also present in the right lobe.

Types and Location of Injuries of the Liver.—The types of injuries to the liver were described by Amante [7] and more recently by Andersson.[12] The most common are lacerations of the capsule and adjacent parenchyma, variable in length, shape and depth. These were present in forty of the fifty-three torn livers. Avulsion of a piece of liver may occur, with such lacerations, but this is rare; or there may be com-

11. Thöle, F.: Verletzungen der Leber und der Gallenwege, Neue Deutsche Chir., 1919, vol. 4.

12. Andersson, L.: Ueber zentrale Leberrupturen und ihre Komplikationen, verzugsweise Abszesse, Beitr. z. klin. Chir. **135**:696, 1926.

minution of a portion of the liver, and pieces of it may be found free in the abdominal cavity. The last kind of laceration was present in one body.

The second type of injury is extravasation of blood into the capsule from tears of the parenchyma alone, and is sometimes referred to as "subcapsular hematoma." The amount of bleeding varies from that covering a small region a few millimeters in diameter to that covering one or more lobes. Such lacerations occurred in eleven bodies, in three of which lacerations of the first type were also present. The third type of injury, a deep tear which does not extend to the surface, with accumulation of blood within the liver, is rare and was not present in any of the bodies.

In twenty-four of the forty-seven livers in which the right lobe was torn, the lacerations extended into the convex surface, in eighteen into the concave and in five into both. The left lobe was torn four times through the convex surface and six times through the concave. In about half of the fifty-three torn livers, there was more than one tear in each; the greatest number in any single liver was ten, counting those in both main lobes. Their depth varied from 0.2 to 3 cm. to the complete crushing of a part.

Lacerations involving the upper surface of the right lobe are usually transverse and perpendicular to the middle sagittal plane; on the convex side of the left lobe and near the suspensory ligaments, the tears are often parallel to it. On the concave sides of the right and left lobes the tears also occur across the trunk from side to side, but near the outer margin of the right lobe many are found at right angles to the transverse lacerations. These peculiarities of direction were found experimentally by Katayama,[13] who killed dogs, removed the livers at once and dropped them from a height of from 6 to 7 meters. The disposition to tear in certain ways, which he demonstrated, is displayed in the injuries described by Amante in human livers. In the fifty-three bodies, the lacerations, especially those of the right lobe, corresponded fairly well to those described by both authors, but those into the ventral surface of the left lobe were more transverse, and in many livers a continuation of tears in the right lobe were similarly directed.

Hemoperitoneum.—The amount of blood depended on the size of the vessels torn, the duration of life and other factors. The average amount in the fifty-three bodies was only from 150 to 200 Gm. In one there was 1,700 Gm. with a large branch of the portal vein torn; in another, 2,400 Gm. with a laceration across the right lobe and half-way across the left (discussed with injuries of the heart). In this series

13. Katayama, K.: Ueber Stichwunden in gerichtlich-medizinischer Beziehung, Vrtljschr. f. gerichtl. Med. **46**:1, 1887.

practically all of the tears into the ventral surface were produced by direct violence to the lower part of the thorax, which also fractured ribs. Compression which causes the liver to bend or flatten usually makes tears of the concave side.

Associated Injuries of Abdominal and Thoracic Viscera.—The injuries in conjunction with lacerations of the liver, in the order of frequency from the statistics of Thöle, are: stomach, gallbladder, lung, transverse colon, small intestine, kidney, spleen, common bile duct, vena cava, portal vein and pancreas. According to Amante, the order is: right kidney, spleen, intestine and lung. Table 16 shows those presented in this series.

Hemorrhage, thrombosis and embolism of blood clots, fat and liver cells frequently occur. One of the fifty-three torn livers had a gumma in it; another was exceedingly fatty, and atrophic cirrhosis was present in a third. In the body of a man, aged 23, who lived forty-six days

TABLE 15.—*Age Incidence in Three Hundred and Seventy-Seven Bodies**

Years	Bodies
0 to 10	44
11 to 20	35
21 to 30	39
31 to 40	66
41 to 50	66
51 to 60	55
61 to 70	49
71 to 80	15
81 to 90	7

* The youngest was 4, the oldest 88 years. The age of six was not learned.

after the accident, there was an abscess more subhepatic than subdiaphragmatic but clearly in the category of what surgeons regard as "subphrenic." It extended into the loose tissues about the right kidney. The laceration of the liver was large, on its upper surface and only in the right lobe. In another body extensive necrosis of the liver had developed in and about a huge laceration of the concave surface of the right lobe; death had ensued three days after the accident. Usually, hemorrhage caused death.

CASE 12.—A man, aged 28, who was sitting on the curbstone when he was hit by a passing machine, died thirty minutes after he was admitted to the hospital. Necropsy revealed: fracture of the roof of the left orbit; traumatic subpleural hemorrhage of the lower lobe of the right lung; laceration across the convex surface of the right and left lobes of the liver and two shorter adjacent lacerations, 11 and 4 cm. long, respectively. These tears were from 0.2 to 2 cm. deep. The quadrate and caudate lobes were torn transversely across, crushed and comminuted. The sternum was fractured at the third costal cartilage. There were about 200 Gm. of blood in the peritoneal cavity; abrasions of the forehead and right knee were found.

CASE 13.—A woman, aged 35, died on the way to the hospital. Necropsy revealed: fracture of the fifth and tenth thoracic vertebrae and fracture of the

second to the ninth right and the fifth to the twelfth left ribs. There were transverse tears from 3 to 5 cm. in length on the outer surface of the spleen and from 2 to 4 cm. in length on the under surface. In the top of the right lobe of the liver were six tears, in the left, five; on the under surface there were four more in the right lobe. The deepest tear was located where the right and left lobes joined ventrally. The longest tear was a transverse tear on the diaphragmatic surface of the right lobe. The tears were from 0.2 to 2.5 cm. deep. There were 600 Gm. of blood in the abdominal cavity and 640 in the two pleural cavities as a result of the injuries of the thorax. Blood was found in the abdominal wall dorsal to the diaphragm for 8 cm. on each side. There was a great deal of blood about the vessels of the hilum of the liver; it was also found about the pancreas, in front of the abdominal aorta and between the uterus and urinary bladder.

CASE 14.—A woman, aged 50, died two hours after the accident. The diagnosis was fracture of the skull. Necropsy revealed: a broken eighth thoracic vertebra, left humerus, radius and ulna and fractures dorsally of from the sixth to the eleventh left and the third to the tenth right ribs. On the phrenic surface of the spleen there were three lacerations, 2 and 3 cm. long, directed transversely, and from 1 to 5 mm. deep. There were superficial subcapsular hematomas beneath both convex and concave surfaces of the right and left lobes of the liver; in the right lobe near the ventral margin there was a tear 13 by 9 by 9 cm. There were fragments of liver about the right lobe of the liver and in the small pelvis. The upper part of the right suprarenal gland was torn. There was a tear 3 cm. long into the lower lobe of the right lung from its dorsal surface. The soft tissues behind the most cephalad part of the inferior vena cava and around the back part of the margin of the right atrium were wet with blood.

LACERATIONS OF THE SPLEEN AND OTHER ABDOMINAL VISCERA

The spleen was injured in twenty-five bodies (6.52 per cent)—fifteen men, six women and four children. The hemoperitoneum was usually considerable. In nine bodies it consisted of from 600 to 2,000 Gm. of blood from the torn spleen, and in the others, of at least from 200 to 300 Gm.

Associated Fractured Ribs and Visceral Injuries.—Injury of the chest is usually present when the spleen is ruptured.[14] In twenty-two of the twenty-five bodies, there were broken ribs: in ten, ribs of the left side; in five, of the right, and in seven, of both sides. The broken right ribs were the seventh to the eleventh.

The spleen was the only viscus injured in six bodies. In ten there were also tears of the liver (table 16) and other organs; of the lungs and spleen in six, of the left kidney and spleen in one, of the spleen, left suprarenal gland and left lung in one and of the left lung and spleen in another. Traumatic rupture of the spleen and left leaf of the diaphragm was present in one of the bodies.

Usually, there was only one extensive laceration; four was the greatest number in any spleen. As the thorax was injured in all the

14. Chalier, A.: Le rôle des lésions costales dans les ruptures traumatiques de la rate, Lyon chir. **24**:69, 1927.

bodies, there were usually tears at the diaphragmatic pole. Tears in the opposite end were not as common, occurring in only nine bodies, and often were accompanied by tears of the outer surface. The length of the tears varied from 1 cm. to complete separation into two pieces. This happened to two spleens. The average depth was from 4 to 5 cm. More of the lacerations were transverse than otherwise.

Pancreas.—Injury of the pancreas by blunt force is rare.[15] It occurs when the organ is compressed against the spine. Bruises of the pancreas were found in only four bodies. In five others, hemorrhage about the gland is mentioned in the discussion of the manner in which the hemorrhage spreads in and about structures of the back wall of the abdomen.

Broken craniums, extensively comminuted in two, were found in four of the bodies in which the pancreas was bruised; in two the contused pancreas was the only abdominal injury; in one the mesentery and stomach were also bruised. The bruises of the left auricle and ventricle already mentioned were also found in one of these four bodies. In none was there external evidence of injury of the abdomen; in one there was a bruise in the subcutaneous tissues in the midline of the front part of the trunk.[16]

Suprarenal Glands.—Contusions of the suprarenal glands or of the fat about them occurred in eighteen bodies (4.65 per cent); in three there was simply hemorrhage into the fat which adheres to them so intimately. Twelve of the persons in whom these organs were injured died from two to three hours after admission to the hospital; three others died en route. The ribs were fractured in thirteen, the spine in four, the cranial bones in three, a clavicle, humerus or femur each in three (altogether nine) and the pelvic bones in one. Some of the violence to all these eighteen bodies was applied directly to the abdomen or adjacent part of the thorax.

The right suprarenal gland was contused in fifteen bodies, the left only in three, and in none were both injured. In twelve bodies the injuries were lacerations and hemorrhage which involved only the medulla. Apparently, death invariably resulted more quickly from injuries to these glands, regardless of the injuries elsewhere. In twelve there were tears of the liver and other organs (table 16).

Kidney.—The kidney was bruised or torn in twenty-five of the 383 bodies (6.52 per cent). In six it was the only deeply placed structure

15. Lehrnbecher, A.: Ueber isolierte subkutane Pankreasruptur, Beitr. z. klin. Chir. **134**:560, 1924.

16. In the examination of the subcutaneous fat of the abdomen for bruises, the skin and subcutaneous tissues are first reflected as a separate layer on each side, and numerous cuts are made into the fat from its deepest parts outward, but not into or through the skin.

injured.[17] In eleven others, the liver was also torn (table 16). There were lacerations in a kidney and in a lung in two; in the left kidney and the spleen in one, in the spleen, left lung and kidney in another, and in others of the twenty-five; concomitant injuries were a ruptured duodenum, broken ribs (twenty-two bodies), basal in six, and comminuted cranial fractures in three bodies.

The right kidney was torn in nineteen bodies, the left in six. Lacerations of both kidneys were not encountered in a single body.[18] In three the injury consisted in complete severance with crushing of the fragments; in three there were transverse lacerations from 1 to 3 cm. long on the dorsal surface; in another body four lacerations from 4 to 5 cm.

TABLE 16.—*Lacerations of the Liver and Injuries to Other Organs in Fifty-Three Bodies* *

Liver	15
Liver, right lung	4
Liver, right kidney	4
Liver, spleen, right lung, right suprarenal gland	3
Liver, spleen	2
Liver, right kidney, right suprarenal gland, right lung	2
Liver, right kidney, right suprarenal gland, right lung, spleen	2
Liver, heart, right lung	1
Liver, right kidney, right lung	1
Liver, ruptured ileum	1
Liver, right suprarenal gland	1
Liver, spleen, right kidney, heart	1
Liver, left suprarenal gland, heart	1
Liver, ruptured jejunum, bruised sigmoid, torn mesentery	1
ruptured gravid uterus	1
Liver, hemorrhage into urinary bladder (pelvic fracture)	1
Liver, lungs	1
Liver, spleen, left lung, bruised bowel and mesentery	1
Liver, spleen, left lung	1
Liver, left lung	1
Liver, left lung, bruised small intestine	1
Liver, right kidney, right lung, torn mesentery	1
Liver, left lung, torn mesentery	1
Liver, left kidney, heart	1
Liver, torn mesentery, bruised colon	1
Liver, right lung, right suprarenal gland, torn mesentery	1
Liver, right lung, right suprarenal gland	1
Liver, right suprarenal gland, left kidney, left lung	1
Liver, right lung, hemorrhage into mesentery	1

* With the injuries of the liver, the associated tears in the other organs are more often on the right side of the body.

long were present, three behind and one in front; in two the upper pole was extensively torn. Altogether ten tears were found in one kidney of another body; in one, the tear ran across into the renal pelvis;[19] in eight, the injuries were trivial, but there was considerable hemorrhage into the perirenal fat.

17. Although traumatic rupture of the kidney is rare, its occurrence is said to be on the increase from automobile injuries (Marshall, V. F.: Am. J. Surg. **36**:195, 1922).

18. In the review of Küster (Deutsche Chir. Lief. **52**:182, 1896-1902), he found only twelve reports of ruptures of both kidneys; of the right, 142, of the left, 118, in a total of 272.

19. Schede, M.: Verletzungen und Erkrankungen der Nieren und Harnleiter, Handbuch der Praktischen Chirurgie, 1903, vol. 3, p. 944. Schede gives a classification of the degrees of severity of injury of the kidneys from blunt force.

Stomach and Bowel.—In one body, there were contusions of the stomach, pancreas and mesentery. In a second, the bruising of the stomach had led to hemorrhage into its wall, which was so extensive that it was entirely discolored from red to purple. The accompanying injuries were a torn left lung and fractured cranium. In one body, the duodenum was torn in front of the spine, with fractures of the cranium, right tibia and fibula and laceration of the upper pole of the right kidney. In three bodies, the jejunum was torn, and in each the tear extended into the mesentery. One was the body of a man who had been caught between a street car and an automobile. He died on the way to the hospital. Necropsy revealed a huge hemoperitoneum; the bowel and mesentery were the only internal structures injured; there was a tear in the mesentery 8 cm. in length. In a second, lacerations of the liver were present with the torn jejunum; in the third, a bruised sigmoid part of the colon and lacerated jejunum were accompanied by a torn diaphragm and ruptured pregnant uterus, to which reference has already been made.

Lacerations of the ileum were found in four bodies. In all there were many bruises, and when the bowel was contused the mesentery was also bruised close by. The tears were small and regularly opposite the mesenteric border, with the mucosa projecting through the perforation, as a rule. In one young man, who died without operation eighteen hours after admission, there was 700 Gm. of blood in the abdomen, evidently from a torn vein in the mesentery close to the ruptured bowel, 25 cm. proximal to the ileocecal valve. There was also a generalized acute peritonitis, but the other internal injuries were not severe. In another, two of the three perforations of the ileum were repaired; a fractured bony pelvis was found. Death had occurred four hours after admission. In a third, the perforation was 100 cm. proximal to the ileocecal junction, 10 by 2 mm. and slit-shaped; operation was not performed; generalized peritonitis was present; there were three fractured ribs of the left side with a wound of the left lung. Death occurred ten hours after admission to the hospital. The other concerned a woman, aged 76 years, with comminution of one innominate bone; the mucosa pouted through the perforation of the ileum; there were other bruises of the small bowel; the scalp was lacerated, and extensive retroperitoneal hemorrhage was present. The patient died two hours after admission to the hospital.

One of the children, a boy, aged 8 years, was found dead soon after being injured by an automobile. There were lacerations of the penis, perineum and of the anterior abdominal wall, through which the whole small bowel with its mesentery protruded. The bowel was not torn. All of the pelvic bones and the right humerus were fractured.

In two other bodies the distal part of the small bowel was simply bruised, and additional severe visceral injuries caused death. Contusions of the mesentery, as stated, accompanied lacerations of the bowel. Such bruises with or without obvious gross tears and without tears of the bowel were found in the mesenteries of four other bodies, usually with cranial or other fractures and lacerations of other viscera. In one of the four, the bowel was gangrenous where its blood supply had been cut off by the tear in the mesentery; a paralytic ileus, a fibrinous peritonitis and fractures of the right tibia, fibula, astragalus and many ribs were present. Operation was not performed, and death ensued three days after the patient entered the hospital. In one body, the colon was torn in its ascending portion and repaired; no other serious deep-seated injury was found. Death occurred from generalized fibrino-purulent peritonitis eighteen days after the patient's entrance.

The following anatomic diagnosis illustrates how the internal injuries may be combined. It pertains to practically all that was abnormal in any way in the body of a boy, aged 14, who was knocked down and run over by a two ton truck; death had occurred three and a half hours after he was admitted to the hospital. Necropsy revealed: comminuted fracture of the cranial bones; transverse fracture of the right clavicle; bruised frontal lobes of the brain; edema of the brain substance; traumatic lacerations of the mesentery of the small and large bowel, right suprarenal gland and right hand; traumatic hemorrhages deep in the lungs, into the deep scalp tissues, retroperitoneal tissue and upper eyelids and about both clavicles; lumbar needle wound; bloody cerebrospinal fluid; huge hemoperitoneum; marked secondary anemia; multiple bruises of the lungs; multiple external bruises and abrasions; systemic hyperplasia of the lymphoid tissue and persistent thymic lymphoid tissue (status lymphaticus).

THE ROUTES OF SPREADING IN HEMORRHAGE

At least some of the important relations of the way blood from torn vessels infiltrates the adjacent tissues are clinical. Many factors determine the distribution of the hemorrhages, such as gravity, the looseness or compactness of the tissues invaded, the pressure transmitted from the heart, thrombosis, the size and nature of the torn vessels and the time during which bleeding occurs. The extent of some of the hemorrhages was remarkable. Reference has already been made to the astounding amount of blood which occasionally accumulates in the retroperitoneal tissues and to amounts in various places recorded by weight. Additional help to a proper comprehension of this phase of the injuries from motor vehicles will be rendered by details from illustrative separate examinations.

The blood from small tears of the front of the left lobe of the liver of a child, aged 7 years, had spread into the wall of the upper half of the descending colon, the outer coats of the entire distal half of the inferior vena cava and into the mesentery of the middle half of the small bowel. In the body of a girl, aged 6 years, who lived five hours, blood from a laceration, 4 by 5 cm, of the right lobe of the liver extended into the right half of the diaphragm and from there up about the thoracic part of the spine and down into the fat about the right kidney. In the abdomen of a man, aged 46, who died on arrival at the hospital, 205 Gm. of blood was found in the abdomen, about half of it loosely clotted and dorsal to the spleen, which was torn behind for 3 by 4 cm., the other half in the fat about the left suprarenal gland and kidney.

In another body, that of a patient who had been injured by a truck and had died on the way to the hospital, some ribs of the left side were broken, the left lung was torn, and with the hemothorax there was clotted blood 1 cm. thick in the loose tissues of the anterior mediastinum continuous with a hemorrhage into the outer layers of both bronchi, the trachea, aortic arch, left common and internal carotid arteries. From the torn spleen there was also 393 Gm. of blood in the abdomen, and in the back wall of the abdomen blood covered the entire left psoas muscle; it was 7 cm. across at its widest place. Some of the free blood was in the lesser omental cavity. Extension distally about the aorta in the fibro-areolar tissues of its adventitia and in the fat close to it occurred in another body, that of a young man, aged 17, with fractures of the first to the seventh ribs of the left side and the first, tenth and eleventh of the right side, lacerations in all lobes of the right lung and almost complete amputation of the middle lobe; this patient died on the way to the hospital. The drift of the blood from about the thoracic part of the aorta was all the way down to the iliac arteries; the abdominal viscera were uninjured.

With the fractured pelvic bones, the distribution of hemorrhage was interesting, and in different bodies was subperitoneal so as to discolor the entire outside of the urinary bladder a deep purple; about the anal ring, as a large amount of fluid or partly clotted blood, there was hemorrhage in all the tissues between the seminal vesicles and rectum, upward from the pubic region in the anterior abdominal wall to the navel, downward into the fat of Scarpa's triangle and in the mesosigmoid so as to swell it to several times its normal thickness. It may be contended that the blood in some of these regions was due to other and undetected injuries, but the routes of spreading were encountered in many bodies and always in places in which the tissues are most easily split apart. Moreover, similar hemorrhages occur from disease, unassociated with trauma, and for many control experiments are encountered in the dispersion of blood following bullet wounds.

FAT EMBOLISM

In bodies with fractured bones, fat was not sought in the blood with any regularity. It was always found when desirable, even when the fractures were of a single rib, clavicle, os calcis or the cranial bones. Two methods were found practical. In sunlight, the oil droplets are easily seen with unaided vision on the blade of a knife or in blood which flows onto large surfaces made when the lungs are cut. The knife should be clean and dry and should possess a long cutting edge. Large surfaces should be made. The lungs are first slipped out of the chest and, without their attachments being severed, are laid on the wall of the thorax after its front layers are reflected, each on its corresponding side.[20] Another method is the aspiration of blood from the pulmonary veins close to the heart and from one or both sides after the pericardium is opened. By sucking with the mouth, it is drawn up into sterile glass tubes closed by cotton at one end and drawn out to a point at the other. The point is broken and a column of 8 or 10 inches (20.3 or 25.4 cm.) of blood collected; the tube is then sealed at the drawn out end. When such long pipets are kept erect over night in an icebox, a layer of oil is found at the top in the morning. The layer is yellow and from a few millimeters to 1 or 2 cm. thick. The sides of the tube appear oily at the top of the column of fluid after the tube is tilted and returned to the vertical position. A minute portion of the top of the column may be withdrawn and examined microscopically.

These two methods were supplemented by the customary examination for fat with stains of sections of fixed tissues made after freezing.[21] There is no doubt that fat embolism frequently contributed heavily to the cause of death. It was most pronounced with fractures of the long bones, and more when the skin was unbroken and the extremity was tense and extensively purple from deep bleeding. Apparently, the entrance of oil from the marrow and torn adipose tissue into torn veins is greatly promoted by the increased pressure of large subcutaneous hemorrhage. Careful examination of the surface of the skin of the neck, shoulders and chest resulted in the discovery of embolic hemorrhages due to fat in many bodies with fractures of the long bones in extremities heavily discolored by deep bleeding. Such minute hemorrhages are bright red, not elevated and rarely below the thorax; they are commonly overlooked during life.

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20. Chiari, H.: Pathologisch-Anatomische Sektionstechnik, ed. 2, Berlin, H. Kornfeld, 1907, p. 48.

21. Some of these observations are reported in LeCount, E. R., and Gauss, Harry: A Study of Fat Embolism Associated with Fractures, Tr. Path. Soc., Chicago **9**:251, 1915.

COMMENTS AND CONCLUSIONS

It is apparent that many who are injured by motor vehicles sustain fractures of the cranium, and that in these the bones of the face are sometimes also broken. There is no evidence that these injuries are received while the victim is still erect, and we have failed to find, by postmortem examination, much evidence of crushing of the head beneath the wheels of the vehicles, although this probably occurs occasionally. On the other hand, there are many reasons for believing that the injuries of the head are caused by violent propulsion of the head downward and its abrupt arrest by a hard road. Some of the other injuries are probably received when the person is lying down, and others, especially those to the upper part of the trunk, are inflicted when the body is erect. They are a consequence of impact with the vehicles.

More of the injuries are on the right side, especially fractures of the skull. Injuries on both sides of the body are rare, and symmetrical injuries still more so. This prevalence of injuries of the right side may be due to traffic conditions, but confirmation is needed by a study of the results of automobile accidents in places where the currents and management of street traffic are different from those in Chicago. However, it seems likely that many are injured by passing behind a car that is not moving and being knocked down by another passing from left to right on the wrong side of the street. Others presumably fail to look both ways under other circumstances.

In a number of bodies there were lacerated or crushed viscera or other deeply placed injuries and slight, if any, external evidence of trauma; in some of these bodies there were no broken bones. It is apparent also that even the most painstaking examination of those injured by motor vehicles may fail to disclose all of the internal injuries or the full extent of those ascertained.

Injuries in such numbers and extent and of so many important parts as were found in some of the 383 bodies are probably always fatal. Assurance of such an outcome, however, is by no means as great as is the reality of the facts in this review of records of necropsies. Assuming, however, that the injuries described for some bodies possess little clinical importance, because death takes place soon after the accidents, an understanding of the entire range of the results of violence from motor vehicles nevertheless has value as a background and stimulus to clinical study.

TANNIC ACID TREATMENT OF BURNS

END-RESULTS IN ONE HUNDRED AND FOURTEEN CASES COMPARED WITH THREE HUNDRED AND TWENTY TREATED BY OTHER METHODS *

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The tannic acid treatment has been accepted by many physicians as the most efficient method of caring for the damaged area of the body surface in cutaneous burns. Davidson advised its use three years ago, and since that time numerous papers concerning this form of therapy have been published; however, none of the authors have reported a large series of cases or compared a series with cases in which other treatment was used.

Four hundred and thirty-four patients suffering from burns were admitted to the Children's Surgical Service, Fourth Division, Bellevue Hospital, between June, 1919, and August, 1928, a little more than nine years. Most of the burns were severe, of second and third degree intensity and involved more than 10 per cent of the surface of the body. The ages of the patients varied from a few weeks to 12 years.

The causes of the burns were equally divided between moist (scalds) and dry heat. Scalds were more numerous in children under 6 years of age, while burns from dry heat were seen more often in the older children.

In this series of cases, 320 of the patients were treated prior to November, 1925, and 114 after this date. The type of treatment used in the first group varied in detail. The open treatment of the wound, by means of the hot air tent, was used in all cases; in a few, paraffin was applied to the wound, and in many sodium bicarbonate baths were employed. The 114 patients in the second group were treated by the tannic acid method. In both groups the fluids were forced, though in the last two years this treatment has been carried out earlier and more intensely.

The conditions present in the two groups were similar, the types of burns did not vary and the ages of the patients appeared to be equally scattered. The number of cases in each group was large enough to make a comparative study fairly accurate.

MORTALITY IN GROUP OF FOUR HUNDRED AND THIRTY-FOUR PATIENTS

In the first group, there were eighty-nine deaths, a mortality of 27.8 per cent, and in the second group seventeen died, a percentage of 14.9. The accompanying table demonstrates these facts more clearly;

* Submitted for publication, Nov. 26, 1928.

in the first group, there were eighteen deaths within twenty-four hours, presumedly from shock, 5.6 per cent of the total number of patients in the group; in the second group, there were six deaths, 5.3 per cent. From the second to the tenth day inclusive—the period of toxemia—there were fifty-seven deaths in the first group and six in the second, a mortality of 17.8 per cent for the former and only 5.3 for the latter. Fourteen deaths occurred after ten days in the first group, 4.4 per cent, and five in the second, a percentage of 4.3.

Chart 1 shows the percentage of deaths which occurred each day after the inception of the burn. During the first day, the percentage in both groups is similar; during the second twenty-four hours, it rises to 7.2 in the first group, while it rapidly falls to 0.8 in the second. Not until the fourth day does the death rate of the first group fall to the level reached by the second at the end of forty-eight hours. From this time on the curve of the first remains slightly higher than that of the second, until the beginning of the third week, from which time both continue on the same level.

Causes of the Deaths in the Group of Four Hundred and Thirty-Four Patients

	Other Treatments		Tannic Acid Treatment	
	Number	Per Cent	Number	Per Cent
Total cases	320	....	114	....
Total deaths	89	27.8	17	14.9
Deaths from shock (first 24 hours)	18	5.6	6	5.3
Death from toxemia (second to tenth day)	57	17.8	6	5.3
Late deaths (after ten days)	14	4.4	5	4.3

During the first twenty-four hours, the percentage of deaths was about the same in the two groups. As death at this time is usually due to shock, it is evident that the tannic acid treatment will not affect its outcome.

Apparently, toxemia develops rapidly after the inception of a burn, and in the majority of patients who die from it the fatality results within seventy-two hours. If the absorption of the toxins is prevented immediately, many of these deaths can be avoided. Apparently, the tannic acid treatment does this, thereby reducing the number of deaths in this period by three fourths (e. g., from the end of twenty-four hours to the end of seventy-two hours, first group, 10.8 per cent; second group, 2.4 per cent) and by two thirds in the period of time between the end of the first and tenth days.

In the period following that of the toxemia, the death rate in the two groups is the same. Deaths during this period are due to sepsis, pneumonia and malnutrition. Although the decrease in the mortality rate from treatment with tannic acid is not apparent, it is probable that a larger percentage of persons with severe burns, who formerly would have died from toxemia, live to reach this later period and are conse-

quently subject to infection and malnutrition; some of them succumb to these conditions.

In the two groups, the average number of hospital days for patients with burns shows a longer stay of six days for those treated with tannic acid. The average number of days for the former group was thirty-four and for the latter, forty. These figures were calculated after the patients who died and those who remained in the hospital less than two days were removed from the series. Among the latter were

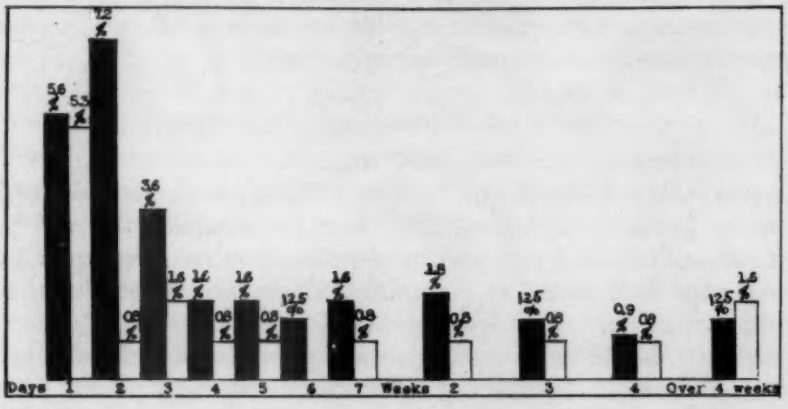

Chart 1.—Comparison of the percentage of deaths per day of the 320 patients treated by various methods (black) with the deaths in the group of 114 patients treated with tannic acid (white).

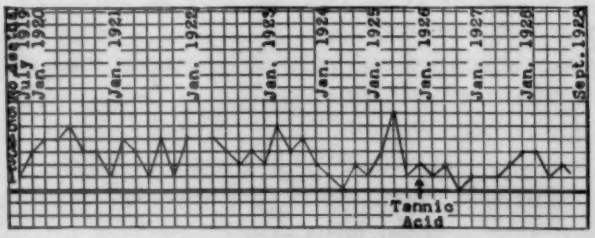

Chart 2.—Deaths per ten cases in the series of 434 cases of burns. It should be noted that the curve is lower after July, 1925, at which time the treatment with tannic acid was first started.

a number of patients who left against advice. There were 7,439 hospital days with 219 cases in the first group, and 3,901 hospital days with 96 cases in the second group. It is probable that the increase of time in the hospital for those treated by tannic acid is due to the fact that those with severe burns who formerly would have died lived, but required a longer period of time to recover. In the first group of 320 patients there were only 11 who remained longer than 100 days (3.4 per cent), the longest period in the hospital being 168 days. In

the group of 114 patients treated with tannic acid, there were 7 who remained longer than 100 days (6.2 per cent); the longest stay was 369 days.

In addition to the facts stated, it is my observation that the tannic acid treatment produced more rapid healing in the second degree burns, that in the third degree burns the granulation tissue of the wound was in the most suitable condition for skin grafting immediately after separation of the tanned eschar, thereby promoting early healing and lessening of the formation of scar tissue, and that there was less pain to the person suffering from a burn treated by tannic acid than to those treated by one of the methods formerly used.

TECHNIC OF TANNIC ACID TREATMENT

The technic of the tannic acid treatment, as carried out on the Children's Surgical Service of Bellevue Hospital, is similar to that laid down by Davidson in August, 1925, with the exception that a 5 per cent solution has been used and the same solution has been applied to burns of the face, instead of the tannic acid ointment, without injurious results to the eyes.

Recently, in the treatment of patients, particular attention has been paid to the early administration of fluids, in order to prevent blood concentration. It is easier to prevent that condition than to cure it. The most effective manner of administering the fluids is by hypodermoclysis of a 5 per cent dextrose solution. Additional fluids may be given by mouth and rectum. A good working rule is that in twenty-four hours a patient should take at least one liter of fluid for every 25 pounds (11.3 Kg.) of body weight.

Opiates should be used sparingly, as their action of lessening secretions is a contraindication to their use.

SUMMARY

1. The tannic acid method of treating cutaneous burns is the most satisfactory treatment so far advocated.

2. The mortality has been decreased from 28 to 15 per cent in a series of 434 cases of burns in children.

3. This decrease of mortality is the result of lowering the death rate from toxemia by two thirds.

4. Toxic absorption in burns takes place within twenty-four hours of the occurrence of the burn. The greatest mortality from toxemia occurs in the period of time between the end of the first twenty-four hours and the end of the third day.

5. The average hospital stay of patients was increased six days by the tannic acid treatment. This is probably the result of the fact that patients with severe cases of burns lived who otherwise would have died.

ABNORMAL ARTERIOVENOUS COMMUNICATIONS

DIAGNOSED FROM THE OXYGEN CONTENT OF THE BLOOD OF THE REGIONAL VEINS *

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One of the striking sequelae of arteriovenous communication is the change occurring in the proximal and distal portions of the affected veins, as evidenced by the dilated appearance of the immediate receiving group of venous channels; the intravenous pressure is increased, since the veins receive blood directly from a vessel in which the pressure is higher. The veins assume the anatomic and functional characteristics of arteries and thus become arterialized. The adaptation of the vein to this abnormal strain was studied by Reid,[1] who noted the thickening of the vein with firm walls simulating an artery. The intima was thickened and the media hypertrophied, with a new production of elastic tissue in the internal layer. These changes can be explained as an adjustment to altered mechanical conditions. The interposition of the small arteriolar and capillary bed is lacking in the regional circulation, and the blood pressure does not undergo its normal gradual reduction; the usual metabolic activities and processes incident to the passing of the arterial blood through the capillaries are also lacking.

There are two important diagnostic signs of arteriovenous aneurysm: Branham's sign, a sharp slowing of the pulse with closure of the fistula and the presence of a thrill in the region of the fistulous opening. I have made use of another test based on the detemination of the oxygen content of the blood of the regional dilated veins proximal and immediately distal to the fistula. The following studies have been carried out in a group of cases of arteriovenous fistula of the congenital and acquired forms, to determine the relative value of this test.

METHOD OF OBSERVATION

The oxygen content of the blood taken from a dilated vein proximal to the fistula was determined in eleven cases, in four of which control determinations were made on the blood taken from the median vein in the normal arm. The blood was collected in a centrifuge tube under oil, and the oxygen capacity and content of the venous blood were determined by the Van Slyke gasometric methods. The per-

* Submitted for publication, Aug. 22, 1928.

* From the Division of Medicine, the Mayo Clinic.

1. Reid, M. R.: The Effect of Arteriovenous Fistula upon the Heart and Blood Vessel: An Experimental and Clinical Study, Bull. Johns Hopkins Hosp. **31**:43, 1920.

centage of the saturation of oxygen in the venous blood was calculated from the ratio of the oxygen content over the oxygen capacity.

Normally, the arterial blood taken from an artery of the upper extremity has an oxygen capacity of 21 per cent by volume, but the blood in passing through the lungs does not take up its entire quota of oxygen, so the blood usually has an oxygen content of about 20 per cent by volume or has taken up 95 per cent of its quota of oxygen. The blood, in passing through the capillaries of the tissue, loses approximately 25 per cent of its oxygen, which leaves 70 per cent saturation of oxygen in the venous blood, or an oxygen content of 14 per cent by volume. If a specimen of arterial blood is collected under oil and compared to one of venous blood collected in the same manner, the difference in color is most striking. This is due to the different saturation with oxygen.

TABLE 1.—*Venous Blood from Dilated Veins in the Region of the Arteriovenous Fistula*

Oxygen, per Cent by Volume				Saturation, per Cent	
Case	Capacity	Content	Unsaturation		Types of Fistula
1	17.9	17.1	0.8	95	Congenital; right foot
2	22.8	20.5	2.3	90	Congenital; right upper arm
3	20.4	20.2	0.2	99	Congenital; right lower arm
4	23.0	18.6	4.5	81	Traumatic; right subclavian artery and vein
5	23.2	18.2	5.0	78	Traumatic; left femoral artery and vein
6	20.7	17.4	3.3	85	Traumatic; carotid artery and jugular vein
7	23.6	22.1	1.5	94	Traumatic; temporal artery and vein
8	23.0	20.7	2.3	90	Traumatic; vessels of hand
9	23.5	22.3	1.2	94	Traumatic; vessels of right hand

TABLE 2.—*Venous Blood from the Regional and the Normal Vein in Cases of Arteriovenous Fistula*

Oxygen, per Cent by Volume				Saturation, per Cent	
Case	Capacity	Content	Unsaturation		Source of Blood
2	22.8	20.5	2.3	90	Dilated vein in region of fistula; right arm
	....	7.0	15.8	30	Median vein in left arm
3	20.4	20.2	0.2	99	Dilated vein in region of fistula; right arm
	....	11.3	9.1	55	Median vein; left arm
4	23.1	18.6	4.5	81	Dilated vein in region of fistula of left subclavian artery and vein
	....	15.5	7.5	67	Median vein; right arm
6	20.7	17.4	3.3	85	Vein in region of fistula of right carotid artery and jugular vein
	....	11.1	6.9	61	Median vein; left arm

RESULTS OF OBSERVATION

The mean value of the oxygen content of the venous blood in the dilated veins in the region of the fistula in all cases was 19.7 per cent by volume, or an oxygen saturation of 94 per cent. In cases 1, 3, 7 and 9 (table 1), the blood in the veins adjacent to it was practically pure arterial blood; the oxygen content was that of arterial blood with a percentage of saturation of oxygen varying from 94 to 99. The other cases showed varying degrees of admixture of venous and arterial blood, the percentage of saturation varying from 78 to 90. Table 2 shows the data in four cases in which studies on oxygen were carried out on blood from the regional veins of the affected extremity and on venous blood taken from a vein in an unaffected region.

COMMENT

This study is further evidence of the arterialization of the receiving veins regional to the arteriovenous communications. Holman [2] showed that the magnitude of the increase of the blood volume in experimental arteriovenous fistula varies directly with the size of the opening. Similar relationships were demonstrated for the variations in blood pressure and pulse. No doubt the size of the fistula determines the degree of the arterialization of the venous blood in the proximal veins, and this relationship has been assumed in studies in the human subject. In the congenital forms of arteriovenous connection with multiple openings, this premise is not valid.

The usual diagnostic signs of arteriovenous fistula have been mentioned. Further important regional signs are: (1) the presence of dilated veins in which pulsations are often observed; (2) the increased heat in the affected areas due to large amounts of arterial blood in the surface vessels; (3) nutritional changes or gangrene in the distal parts, and (4) changes in the systemic blood pressure. The retardation of the pulse with closure of the fistula is a significant sign, but in my experience has not always been conclusive. Moreover, in the congenital forms, closure of the multiple fistulas was not possible. Similarly, differences of opinion have arisen in individual cases as to the existence of a thrill. Usually the diagnosis has been fairly clear when the clinical signs have been carefully considered. A more exact diagnostic sign is necessary, especially if major surgical measures are under consideration. The determination of the presence and degree of the arterialization of the venous blood in the regional veins furnishes this exact information. In two of the cases studied it was the decisive factor in deciding operative treatment. The logical objection to this method is that it entails a highly complicated laboratory method of gas analysis of the blood, if exact quantitative data are necessary. From the practical standpoint, gas analysis of the blood is not essential, since the appearance of the blood is usually conclusive. Blood withdrawn from the regional veins of the fistula is compared with the color of the blood withdrawn from a normal vein, usually from the unaffected arm. The difference in color is usually decisive. In cases of doubt, the percentage of the oxygen saturation should be determined. In my cases the lowest value for the percentage of the saturation of oxygen of the mixed blood in the vein was 78, a value close to that of pure venous blood. A definite difference in the color was apparent in this specimen when it was compared to the unmixed venous blood with an oxygen saturation of about 70 per cent.

2. Holman, Emile: Experimental Studies of Arteriovenous Fistulae, Arch. Surg. **9**:822 (Nov.) 1924.

In the other cases the mixed venous blood had the bright red appearance of pure arterial blood which was verified by the high percentage of oxygen saturation.

SUMMARY

Nine cases of congenital and acquired forms of arteriovenous communications were studied. The percentage of oxygen saturation of the blood from the arterialized veins in the region of the fistula indicated varying grades of admixture of arterial and venous blood in the acquired or single communicating forms. The degree of admixture indicates roughly the size of the arteriovenous communication. The color of the mixed venous blood when compared to the unmixed venous blood obtained from a normal vein is usually sufficient to establish the diagnosis of an abnormal connection between the artery and vein. When this evidence is equivocal, determination of the percentage of the saturation of oxygen can be carried out. The establishment of this sign is absolute evidence of arteriovenous communication.

MALIGNANT METASTASES OTHER THAN TO THE REGIONAL LYMPH NODES*

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Unfortunately, patients with cancer continue to present themselves to the surgeon at an unduly late stage of the disease. The diagnosis of the primary lesion in late cases is usually obvious, and the main problem that confronts the surgeon is the detection of the early distant metastases which contraindicate operation.

The more diligently and more intelligently that metastases are sought, the more commonly are they found, and futile operations on the primary lesion are prevented. Experience has shown that cancer exhibits a predilection to spread along certain pathways that differ with the various organs and tissues. In a few instances the blood stream plays the prominent rôle in conveying cancer cells to a distant focus, especially the lungs; but in the great majority of cases the dominant factor in distant cancer dissemination is lymphatic permeation, as described by Handley in his book on "Cancer of the Breast." I agree with the majority of Handley's views, but I believe he is in error in describing transplantation as the chief factor in the spread of cancer inside the pleural and abdominal cavities. I readily concede that transplantation does occur, but I believe lymphatic permeation accounts for the majority of metastatic lesions, other than in the regional lymph nodes, in these cavities. No one should attempt to treat patients with cancer unless thoroughly conversant with Handley's theory of lymphatic permeation.

Surgeons are familiar with metastases to the regional lymph nodes due to lymphatic embolism of cancer cells from the primary growth, and for the most part further mention of them will not be made.

METASTASES IN CANCER OF THE BREAST

Cancer of the breast may metastasize in many directions, usually, however, within certain well marked limits. By direct extension cancer cells may invade the wall of the chest, including the underlying ribs, "fix" the breast to the wall of the chest and contraindicate radical operation. Early involvement of axillary nodes by lymphatic embolism is too

* Submitted for publication, Dec. 5, 1928.

* Read May 22, 1928, during the Special Study Course in Cancer held under the auspices of the Philadelphia County Medical Society.

well recognized a process to call for more than passing mention. Blood stream embolism of cancer cells does occur, but it is a much less frequent cause of metastasis at the time operation is being considered than is generally believed. Careful observations indicate that lymphatic permeation from the breast causes the majority of the lesions formerly ascribed to blood emboli. Emboli originating in the veins of the breast or in the lymphatic vessels which empty into the thoracic duct lodge in the minute pulmonary arteries or capillaries; as a rule, they are therein destroyed and only exceptionally give rise to lung metastases prior to the latest months of the patient's life, but in this terminal period blood emboli of growing cancer cells in the lung are not uncommon. The rarely encountered distant isolated metastases of cancer of the breast are usually due to embolism by way of the blood stream. Clinical and pathologic evidence indicates that it is rarely possible for cancer cells to pass through the pulmonary vessels and cause distant metastases without the existence either of a metastatic lesion in the lung, or, as reported in one case, of a patulous foramen ovale in the heart. A careful study of the cases of distant metastasis usually reveals evidence of more or less widespread metastases intervening between the cancer of the breast and the distant lesion. For instance, roentgenograms limited to the region of a pathologic fracture of the femur may suggest an isolated lesion, whereas further exposures usually reveal metastases in the pelvic bones, lumbar spine and opposite femur and thereby indicate that the extensions are due to lymphatic permeation rather than to blood embolism.

Lymphatic permeation is the dominant process in the spread of cancer of the breast, but no one can predict in a given case in which direction or directions it will first be manifest. Permeation produces the cancerous nodules of the skin and subcutaneous fat which are easily recognized by inspection and palpation. Experience teaches that when these nodules extend 3 inches (7.6 cm.) or more beyond the center of the cancer in the breast radical operation is contraindicated because it will fail to include "Handley's microscopic growing edge." Permeation is also an active factor in the production of lymphatic and venous obstruction in the region in which the clavicle crosses the first rib. This obstruction, when evidenced by marked swelling of the arm, contraindicates radical operation. By a combination of lymphatic permeation and lymphatic embolism, cancer cells may be carried to the opposite breast or even to the opposite axilla.

In another paper I [1] have shown how lymphatic permeation of cancer cells may affect the bones or the pleura, lungs and mediastinal lymph nodes by a variety of channels or may involve the liver by way of

1. Carnett, J. B.: Surg. Clin. N. Amer. **7**:7 (Feb.) 1927.

Handley's "dangerous triangle" in the epigastric notch. Liver metastasis is a late development. Other contraindications to operation usually exist long before enlargement of the liver can be demonstrated clinically. Osseous and intrathoracic metastases are often present but unsuspected at the time patients with cancer of the breast are subjected to radical operation. Routine preoperative roentgenograms of the lungs and bones will prevent many futile operations. Intrathoracic metastases can be detected by the x-rays earlier than by physical examination. Cancer of the breast is the most common cause of bone metastases in women. Metastases involving all of the bones except those of the forearms, hands, legs and feet are not rare just before death. If the patient's life has been prolonged by radiation, all bones may become involved. At the time of contemplated operation, the bones most likely to be affected are the underlying ribs, the shoulder girdle (humerus, scapula, clavicle) on the same side as the lesion of the breast and the thoracic and lumbar vertebrae. Roentgenograms of the chest should include the ribs and isolateral shoulder girdle, but separate pictures of them should be taken if necessary. Anteroposterior and lateral views of the thoracic and lumbar spine should be a part of the routine examination antecedent to operation in every case of cancer of the breast. In addition, complaints of "rheumatic," "neuralgic" or other obscure pains elsewhere call for roentgenograms to exclude involvement of the bones.

METASTASES IN OTHER CANCERS

As a general rule, untreated primary cancer originating anywhere above the clavicle does not tend to metastasize below the clavicle during the period of operability of the local lesion. There are two main reasons for this general rule. Basal cell carcinomas occur frequently in this area, but as their spread is due almost exclusively to direct extension they do not give distant metastases. Other forms of cancer originating above the clavicle pursue a relatively rapid course, and death or inoperability ensues before distant metastases occur. It is only in the slowly growing cancers, as in those of the breast and prostate, that sufficient time elapses for the development of metastases in the lungs and bones. If a primary cancer above the clavicle is held in abeyance by operation or irradiation so that the patient's life is prolonged, intrathoracic metastases may occur. The most extensive lung metastasis that I have ever seen was in a case of cancer of the tongue in which the local lesions and those in the cervical nodes had been subdued but not cured by operation and radium.

Prickle cell cancer of the skin, especially in the regions of the inner and outer canthus, is prone to invade the orbit, and this likelihood should be taken into consideration in treating the patient even before orbital invasion can be demonstrated by palpation. Prickle cell cancer in the

temporal regions causes a lymphatic permeation of the deeper tissues which demands irradiation in every case. This deeper permeation cannot be demonstrated except by the microscope until very late, usually after healing of the skin lesion itself following excision, desiccation or irradiation and then can first be detected by palpation of a subcutaneous infiltration. Prickle cell cancer of any part of the body may affect adjacent bone by direct extension or may rarely cause a distant bone metastasis by lymphatic permeation. The latter form of metastasis is too rare to call for routine preoperative roentgenograms, but its possibility should not be lost sight of when the patient complains of obscure pain.

Cancer of the external ear resists radiation, calls for wide removal, and causes early embolism to the regional lymph nodes.

The usual cause of failure in the cases of cancer of the lip in which cure is not effected by excision of the local lesion and regional nodes is lympathic permeation of the tissues outside of the operative field. Irradiation of the tissues from above the level of the mouth to the cricoid cartilage and laterally to the buccinator muscles should constitute an integral part of whatever plan of treatment is adopted for cancer of the lip.

Cancer of the tongue is apt to cause bilateral invasion of the nodes of the neck even when the primary lesion is unilateral.

Cancer of the maxillary antrum may break through any of the surrounding bony walls and be demonstrable in the cheek, nostril, mouth or orbit. Roentgenograms will reveal the associated destruction of bone or may frequently show a metastasis to the adjacent paranasal sinuses, particularly the ethmoids. Metastasis to the cervical lymph nodes ordinarily occurs late but rarely it may be found early in the absence of any other symptoms. Hence, in addition to the usual routine examinations for a primary focus, the presence of suspicious nodes in the neck calls for roentgenograms of the antrum.

In cancer of the larynx, the contraindication to operation is usually due to the wide involvement of cervical lymph nodes. By direct extension the cancer may invade the pharynx and esophagus, where its presence is detected best by visual examination. In the late stages, laryngeal cancer may cause intrathoracic metastases.

The metastases in cancer of the esophagus have been described in a recent paper by Clayton,[2] and I will not discuss them here.

In gastric cancer, roentgen examination may demonstrate inoperability because of (1) the wide extent of the lesion in the stomach itself, (2) fixation of the stomach due to direct extension of the growth to adjacent structures, (3) enlargement of the liver or (4) metastases to

2. Clayton, E. S.: Surg. Gynec. Obst. **46**:52 (Jan.) 1928.

the lungs. Physical examination occasionally reveals an enlarged nodular liver, which contraindicates operation. Before operation every patient with a gastric cancer should be examined for (1) the well known Ewald lymphatic node metastasis above the inner end of the left clavicle, (2) metastatic lymph nodes in the left axilla, (3) metastatic lymph nodes of the inguinal and saphenous regions, (4) subcutaneous nodules at or near the umbilicus following lymphatic permeation of the round ligament, and (5) a metastatic deposit at the bottom of the pelvis where the peritoneum is reflected from the rectum to the bladder or uterus. The latter deposit is found by rectal or vaginal examination. It is generally supposed to be transplantation metastasis, but there is good reason to believe that this deposit in some instances may result from lymphatic permeation. If there is any doubt as to the nature of enlarged lymph nodes in the three specified regions, removal of one of the nodes under local anesthesia for microscopic study may save the patient from a more formidable abdominal operation. The finding of metastases by the preceding examinations will reveal the hopelessness of radical operation in the majority of patients with cancer of the stomach at the time they first come under surgical observation.

In the more hopeful minority group, an exploratory incision will demonstrate the impossibility of a curative operation in a high percentage of cases. Before one proceeds with the gastric resection, a careful search should be made for metastases which cannot be removed by the knife. Metastatic nodules in the liver are common and should always be looked for. A patient with gastric cancer, however, may die with extensive metastasis without involvement of the liver. A search should be made for (1) secondary nodules in the omentum and on the adjacent viscera resulting from either transplants or lymphatic permeation; (2) permeation nodules in the mesentery of the jejunum particularly; (3) retrograde permeation enlargement of the lymph nodes along the lower abdominal aorta, especially the lumbar group; (4) the extensiveness of permeation metastases in the immediate regional lymph nodes, though one should bear in mind that considerable enlargement may be due to infection rather than cancer, and (5) evidence of direct extension to adjacent viscera or parietes usually secondary to adhesions. This extensive search requires but a few moments and will often reveal the futility of a radical operation.

Cancer of the intestine affects the large bowel almost exclusively. Cancerous extension to adjacent viscera or parietes may be determined in the rectum by palpation and may be suggested elsewhere by the fluoroscope, revealing fixation of the colon. Distant metastasis is almost exclusively limited to the liver. It is seldom possible to detect hepatic metastasis by physical examination before operation. It should be an invariable rule to make direct palpation of the liver before resorting to

resection of any part of the intestinal tract. This direct palpation may be carried out through the incision either of a preliminary colostomy or of the proposed resection of the intestine but, if necessary, as may occasionally happen in excision or resection, a special incision should be made to permit palpation of the liver. The same abdominal incision provides facility for examination of the metastasis to the lymph nodes and of the direct cancerous extensions to contiguous structures.

Malignant tumors of the kidney commonly metastasize to the lungs before the patient first comes under observation. Nephrectomy for malignant disease should never be undertaken unless the lungs are first found free from metastasis by roentgen examination. Since adopting this rule, I seldom remove a kidney because of malignant disease. Tumors of the kidney may cause bone metastasis; hence, any symptoms pointing in that direction demand further roentgenograms. The bone metastasis is usually an isolated lesion and in the absence of renal symptoms has frequently been mistaken for a primary tumor of the bone; hence it is a wise precaution to apply a tourniquet immediately above any bone lesion in the extremities and make a biopsy before resorting to amputation. At operation, the kidney may show evidence of direct extension of the malignant process to adjacent structures or of a plug of tumor cells filling the renal vein and extending into the vena cava.

Bumpus reported that one fourth of all patients with cancer of the prostate display metastasis to the bones of the pelvis or lumbar spine by roentgen examination at the time of operation. Roentgenograms of these bones are demanded before the surgeon decides on prognosis or treatment. A doubtful diagnosis of cancer of the prostate may be established by finding roentgen evidence in the adjacent bones of an osteoplastic, "chalky" appearance, which is characteristic when found in men. Cancer of the prostate is the most common cause of bone metastasis in men. Any man exhibiting evidence of bone metastasis should be subjected to a careful examination for prostatic cancer. By observance of the latter rule, an unsuspected cancer of the prostate may be found to account for bone metastases otherwise ascribed to an independent cancer known to be present in some other organ or structure, as, for instance, in the stomach, which is not prone to metastasize to bones. Elsewhere, I [2] have described how the bone metastasis of prostatic cancer spreads peripherally and often involves all the bones of the skeleton except those of the forearms, hands, legs and feet.

Metastases to the pelvic and lower abdominal lymph nodes are common in cancer of the prostate, but they are difficult of diagnosis. Their presence is suggested by bilateral pain in the hips and thighs which is due to a nerve pressure not accounted for by roentgen demonstration

2. Carnett, J. B.: Surg. Clin. N. Amer. **7**:31 (Feb.) 1927.

of bone metastasis. Exceptionally, roentgenograms and physical examination may reveal pulmonary metastasis. More rarely, metastatic nodules are encountered in the skin.

Malignant tumors of the testis commonly extend through the lymphatic vessels accompanying the spermatic veins and produce bulky metastasis of the retroperitoneal nodes of the upper part of the abdomen. A retroperitoneal mass should be sought by palpation before one resorts to castration. Exceptionally, the testicular tumor may be relatively latent and small; hence, any retroperitoneal mass calls for examination of the testes. Metastases by way of the venous channels may extend to the lungs, liver, brain and kidneys.

I am not familiar with malignant disease of the female sexual tract, and Dr. C. C. Norris has furnished me with the following details relative to metastasis: Carcinomas of the external genitalia and outer half of the vagina metastasize to the inguineal lymph nodes and may cause permeation nodules of the perineum and lower anterior abdominal wall. Cancers of the cervix and of the inner half of the vagina metastasize along the base of the broad ligament, often to the group of lymph nodes lying within the bifurcation of the common iliac vessels and only rarely beyond the limits of the pelvis. Cancers of the uterine fundus metastasize commonly to the upper part of the abdomen and occasionally along the round ligaments to the inguinal lymph nodes. The metastases of ovarian cancer are usually confined to the pelvis, but rupture of a malignant cyst may cause transplants throughout the pelvis and abdomen.

Sarcomas metastasize mainly by means of tumor cell emboli which enter the venous system in the primary lesion and are carried through the right side of the heart to lodge in the capillaries or smaller arteries of the lungs. Embolism causing pulmonary metastasis may occur early in a sarcoma situated anywhere along the course of the systemic circulation. It is therefore obvious that roentgenograms of the lungs, preferably stereoscopic, are always indicated before one arrives at a decision as to the treatment and prognosis for sarcoma. The finding of sarcomatous deposits in the lungs is sometimes helpful in determining the nature of an uncertain primary growth. The tumor cells which enter the venous system from the metastatic sarcoma of the lung pass through the left side of the heart and are distributed in the most haphazard fashion anywhere along the arterioles of the systemic circulation. No one can predict where these secondary emboli will lodge and produce tumors. As a rule, the haphazard distribution of metastatic nodules indicates sarcoma rather than carcinoma. Infrequently, sarcoma develops in the area of the portal circulation, and the primary metastasis will then appear in the liver. Lymphosarcoma habitually spreads by way of the

lymphatics and other forms of sarcoma occasionally display a tendency to invade the lymphatics; hence the regional nodes should always be examined.

COMMENT

The instances cited constitute the vast majority of cases of malignant disease encountered in practice. All too frequently metastases which prohibit operation have taken place before the patients apply for treatment. One can only hope that continued propaganda will result in earlier diagnosis and the institution of treatment before distant metastases have occurred.

THE EFFECT OF BONE TRANSPLANTATION ON THE BLOOD CALCIUM LEVEL*

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CHICAGO

The more radical removal of thyroid tissue for the cure of thyrotoxic states has resulted in an appreciable increase in the number of acute and chronic cases of postoperative tetany in recent years. Clinical observations and experiments with animals have established the relationship between the injury to the parathyroid glands and the symptoms of tetany with a simultaneous fall in the blood calcium level. As the symptoms of tetany disappear, the calcium rises and reaches its normal level. Because of the relationship between tetany and hypocalcemia, it is logical to speculate that any method which could raise the blood calcium level, would, at the same time, cure tetany.

The greater number of cases of postoperative tetany are mild and transient, and can be combated successfully by large doses of calcium salts given by mouth. The more severe cases, however, present a formidable problem and tend to become chronic. Homotransplantation of a parathyroid gland obtained from a dying man or in the course of strumectomy is obviously an uncertain, casual and impracticable method. Transplantations of parathyroid glands from cattle have been successfully performed and have given alleged good results. The method, however, is not satisfactory because of the lack of reliability and the asepsis of the obtained material. Moreover, all transplants are sooner or later absorbed.

The work of Kramer and Tisdall[1] has established that the calcium of serum or plasma is remarkably constant for a large variety of normal animals, varying in man, dog, rat, sheep and cow, from 9 to 11 mg. per hundred cubic centimeters of serum. Another well established fact is that no amount of calcium given by mouth or intravenously is capable of permanently raising the blood calcium level. In the light of our present knowledge of the rôle assigned to the electrolytes, calcium,

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* Submitted for publication, Nov. 21, 1928.

* From the Department of Experimental Surgery and the Department of Physiology of the Northwestern Medical School.

1. Kramer, B.; Tisdall, F. F., and Howland, J.: The Clinical Significance of Calcium Concentration in the Serum of Children and Possible Errors in its Determination, Am. J. Dis. Child. **22**:560 (Dec.) 1921. Kramer, B., and Tisdall, F. F.: The Distribution of Sodium, Potassium, Calcium and Magnesium between the Corpuscles and Serum of Human Blood, J. Biol. Chem. **53**:241, 1922.

potassium, sodium and magnesium, in a number of complicated physiochemical processes, such as osmosis, diffusion, permeability of cell membrane, and in view of the antagonism between calcium and potassium and the necessity for the proper concentration of each, the existence of a fine, automatic, regulating mechanism is not at all surprising.

The blood calcium level can be raised for a short time by the injection of parathyroid extract-Collip. Subcutaneous injections of parathyroid extract raise the calcium content of the blood and prevent the occurrence of muscular spasms of tetany. The parathyroid extract takes the place of the specific hormone of the parathyroid tissue. In this respect, the action of this compound is analogous to that of insulin. The cessation of its administration results in a return of symptoms.

In the recent literature there have appeared isolated reports, principally from the clinic of the well known Russian surgeon, W. A. Oppel of Leningrad, to the effect that it was possible in their experience to raise the blood calcium level by means of a bone transplant. The first hint that a bone transplant can raise the blood calcium level was obtained when it was found that a tuberculous person on whom an Albee operation for Pott's disease had been performed, exhibited a rise in the blood calcium level. Schmidt and Obrastzow,[2] of the same clinic, experimented with twelve rabbits. In five, a heterogeneous bone transplant was made, on another five a homogeneous transplant and on the remaining two rabbits a sham operation was performed. The average for the blood calcium level in the two control animals was 11.9 mg. before and after the operation. In the group in which the heterogeneous transplant was made, the blood calcium level rose from the average of 12.2 to 12.7, a rise of 0.5 mg., or a 4 per cent increase. This rise was noted as late as three months after the operation. In the homoplastic series, the calcium level rose from an average of 11.9 to 13, or 9 per cent.

The method was then given clinical application, the results of which were reported on by J. M. Krinizki [3] in a paper published in the *Archiv für klinische Chirurgie* for 1927. The following technic was used: A piece of beef-bone from 4 to 6 cm. long by 3.5 by 0.5 cm. wide was stripped of its periosteum and was boiled for two hours in a 2 per cent soda solution on the day previous to the operation. On the day of the operation it was again boiled for two hours in a physiologic solution of sodium chloride. The bone was implanted in a pocket made between the subcutaneous tissue and the superficial fascia of the pectoral region. Six patients with classic symptoms of tetany were thus treated. Symp-

2. Schmidt, A. A., and Obrastzow, G. D.: Zur Frage der experimentellen Calcarämie, Biochem. Ztschr. **172**:262, 1926.

3. Krinizki, J. M.: Zur Behandlung der Tetanie und Spasmophilie bei Erwachsenen mittels Knochentransplantation, Arch. f. klin. Chir. **147**:530, 1927.

toms began to disappear as early as the fifth day after the transplantation. Faradic irritability to 1.5 milliamperes changed to that of 3.5 milliamperes; the Chvostek and Trousseau signs could no longer be elicited. The patients felt well and were able to return to work. The blood calcium level began to rise at the end of the second week. It rose from 1 to 2.5 mg., and remained at this high level three months later.

The phenomena observed were explained on the following theoretical basis. The effect of a bone transplant is more than that of a calcium depot. The transplant is a foreign body, and the organism in trying to absorb it causes calcium ions to be absorbed into the circulation. Apparently all of the skeletal tissue is irritated to mobilization of calcium ions, because the effect remains even after the removal of the transplant as shown in the experiments of Schmidt and Obrastzow. An undetermined relationship seems to exist between the transplant, the parathyroid hormone, the blood and the tissues.

The results quoted are important if true, because they furnish an easy method for the control of a grave condition, and because they establish a biologic principle.

In our own experiments we felt that utmost accuracy and prolonged observation were more important than the number of animals. The effect of bone transplantation was studied in three dogs and three rabbits. The animals were fed the ordinary laboratory diet. For determination of blood calcium, we used the micrometric method of De Waard [4] as modified by Kramer and by Collip and Clark. For each determination, duplicate samples of serum were run. Determinations were made on 2 cc. of serum. In the rabbits, the blood was obtained from the marginal ear vein by the method of partial venesection. Only occasionally were we compelled to make determinations on 1 cc. samples in rabbits. They, however, checked favorably with 2 cc. samples.

The serum calcium was determined for each animal at about weekly intervals for a period of at least four weeks. Following the operation of bone transplantation, the serum calcium was determined at varying intervals for not less than six weeks. Homogeneous transplants only were used in our experiments. The technic of the operation was essentially that described in the experiments of Schmidt and Obrastzow.[2] Our results were as follows: The blood calcium in dogs exhibited greater fluctuation during the month following the operation than was previously noted. However, the maximum postoperative serum calcium value was actually lower than the maximum preoperative value, the difference ranging from 0.4 to 0.9 mg. per hundred cubic centimeters of serum. In all three rabbits the blood calcium was found to be from

4. De Waard, D. J.: Eine Microbestimmung des Calciums in Blut, Serum und anderen Substanzen, Biochem. Ztschr. **97**:176, 1919.

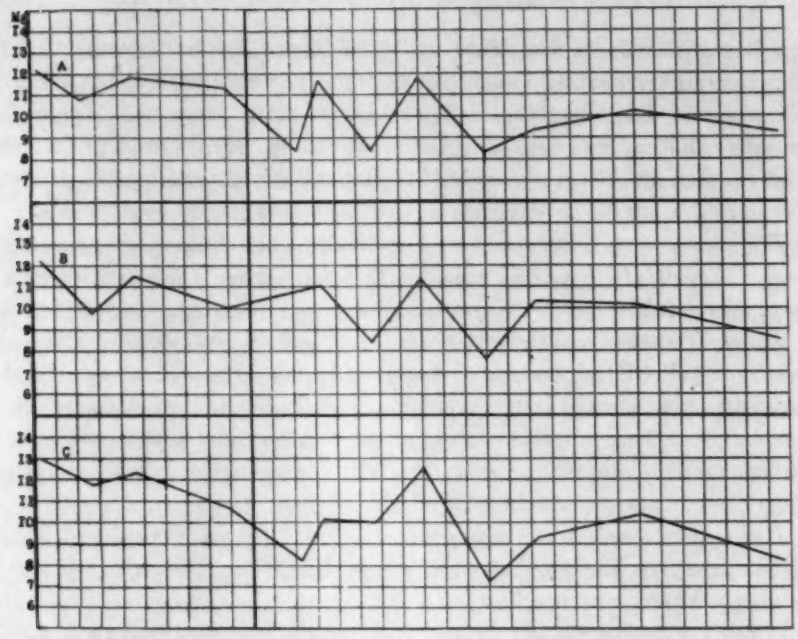

Chart 1.—Blood calcium in normal dogs after an operation of bone transplantation. The numbers at the left signify the milligrams of serum calcium. The area of the square indicates three days time, and the black vertical line, the time of operation in each experiment. *A* represents dog 90; *B*, dog 91, and *C*, dog 92.

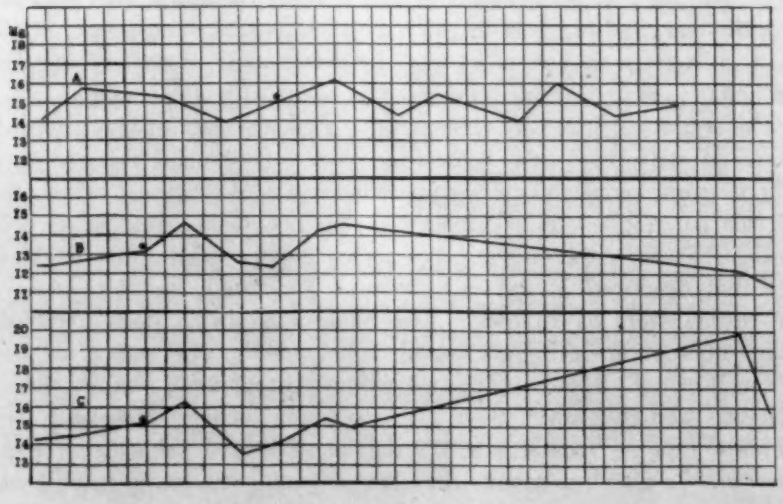

Chart 2.—Blood calcium in normal rabbits after an operation of bone transplantation. The numbers at the left signify the milligrams of serum calcium. The area of the squares indicates three days time, and the stars, the time of operation in each experiment. *A* represents rabbit 93; *B*, rabbit 3, and *C*, rabbit 2.

0.2 to 1.6 mg. higher than the maximum preoperative value. This rise, however, was inconstant appearing, as can been seen from the charts one week after the operation, sinking to normal or lower, and rising one month later.

Our experiments, carried out with all precautions known and for a sufficient period of time, have given us a definitely negative result in dogs. The changes in the rabbits were both inconstant and certainly not above normal variations. Besides, we have gained the impression that the blood calcium level in rabbits is not nearly as constant as it is in dogs. This impression finds confirmation in the recently published results of W. H. Brown,[5] and of Grant and Gates.[6] Brown, after repeated and prolonged observations on an unusually large number of rabbits, stated that the blood calcium in rabbits is influenced by seasons and by environment. The range of normal variation is from 14 to 16 mg. per hundred cubic centimeters of serum. In the experience of Grant and Gates, caging rabbits for periods of seven weeks increased the calcium content of blood.

Since the normal organism is not in need of increased blood calcium, one could predict *a priori* that the same regulating mechanism would neutralize the alleged activating effect of a bone transplant on the mobilization of calcium ions. Our results do not throw any light on the question of the ability of the bone transplant to raise the blood calcium level in hypocalcemic states. We are attempting at the present to work out a method of induction of a more or less permanent state of hypocalcemia. The effect of bone transplantation on such a state would furnish the experimental basis for the evaluation of this method in cases of tetany.

CONCLUSIONS

1. Homogeneous bone transplants in normal dogs and rabbits fail to raise the blood calcium level. The changes noted were not in excess of normal variations.

2. The blood calcium level in rabbits is not as constant as it is in dogs. The changes observed by Schmidt and Obrastzow were well within the limits of normal variations.

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5. Brown, W. H.: Calcium and Inorganic Phosphorus in the Blood of Rabbits, J. Exper. Med. **47**:539, 1928.

6. Grant and Gates: Some Factors Affecting the Levels of the Serum Calcium and Phosphorus of Normal Rabbits, Proc. Soc. Exper. Biol. & Med. **22**:315, 1925.

SYNOVECTOMY IN CHRONIC ARTHRITIS*

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HISTORY

Removal by operation of the synovial membrane from any articulation is called synovectomy. The first mention in surgical literature of this operation was made by Volkmann in 1877. The operation he described was the removal of the synovial membrane of a tuberculous knee. In 1895, Alberton reported two successful cases in which the operation was performed through lateral incisions for chronic infectious arthritis following penetrating wounds of the knee. The first record of a complete synovectomy in chronic arthritis is an article by Mignon [1] in 1899, in which he reported the removal of all the synovia from the anterior compartment of the knee. In a patient with chronic traumatic arthritis with hydrops of the joint, he reported a complete restoration of function in six months. Goldthwaite,[2] in 1900, reported a series of partial synovectomies with good results.

The literature contains nothing more of importance until 1916, when Murphy [3] reported two cases of synovectomy in so-called hypertrophic villous synovitis. His technic included a horseshoe incision in the skin with the base above and a transverse division of the ligamentum patellae.

The next mention was made in 1919. At this time Burghard [4] stated "that the synovial membrane, in whole or in part, infrequently must be removed due to hypertrophy, or on account of being covered with papillary growths." Excellent results were reported. In 1921, Skillern [5] reported a case of synovectomy of the knee. Swett, in 1922, reported the first series of synovectomies in chronic polyarticular arthritis before

* Submitted for publication, Dec. 26, 1928.

* From the Orthopaedic Service of the Massachusetts General Hospital.

1. Mignon, A.: Synovectomie du genou, Bull. et mém. Soc. de chir. de Paris **26**:1113, 1899.

2. Goldthwaite, J.: Knee-Joint Surgery for Non-Tuberculous Conditions, Brit. M. & S. J., 1900, p. 286.

3. Murphy, J.: Hypertrophic Villous Synovitis of Knee Joint in Synovial Capsulectomy, Surg. Clin., Chicago **5**:155, 1916.

4. Burghard, F. F., and Kanavel, A. B.: Oxford Loose-Leaf Surgery, Oxford, 1918-1919.

5. Skillern, P. G.: Hypertrophic Vilous Synovitis of Knee Joint; Synovial Capsulectomy, Internat. Clin. **4**:61, 1921.

the American Orthopaedic Association. His first paper included a series of eight synovectomies. He cautioned against the wholesale use of synovectomy. He advised that the originating foci of infection should be eliminated and proposed that synovectomy should be tried only when nonoperative methods of treatment had failed. With one exception, he reported marked improvement. In six cases, the operation was followed by general improvement with an amelioration of the signs and symptoms of other involved joints. It was his further opinion that the operation was of distinct benefit in chronic infectious arthritis when extensive cartilaginous damage had not already occurred. In a further discussion in 1923, Swett [6] stated that out of twenty synovectomies, about seventeen patients were definitely benefited. Jones,[7] in 1923, reported twelve cases of complete synovectomy in which he used the split patellar incision. He stressed the importance of careful selection of cases and stated that only twelve were selected for treatment out of about 300 cases of chronic arthritis of the knee joint; he reported good results in these.

In 1923, Steindler [8] reported a series of twelve cases in which the time of observation ranged from three months to fourteen months, and in which end-results were obtained both in mobility and in alinement, and in weight-bearing function. Weight-bearing was painless in eight, fair in three and poor in one. Alinement was good in eleven and poor in one. Mobility was decreased in five, reduced to nothing in two, increased in two and enlarged to full motion in three. By means of careful histologic data, irrespective of the clinical classification, Steindler distinguished three groups pathologically: first, traumatic cases; second, chronic inflammatory quiescent cases, and third, chronic recurrent inflammation. In the first group there were four cases; in the second, three and in the third group five. He concluded that the removal from the knee of obnoxious tissues which stand in the way of complete correction and perfect alinement is justified, because while not productive of increase in motion, it is productive of good alinement and of painless weight-bearing function.

In 1924, Speed [9] reported eleven cases of synovectomy of the knee. Five of these were for chronic arthritis and two were for traumatic arthritis. The latter group had both semilunar cartilages removed, and

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6. Swett, P. P.: Synovectomy in Chronic Infectious Arthritis, J. Bone & Joint Surg. **5**:110, 1923.

7. Jones, Ellis: Synovectomy of the Knee Joint in Chronic Arthritis, J. A. M. A. **81**:157 (Nov. 10) 1923.

8. Steindler, Arthur: Synovectomy and Fat Pad Removal in the Knee, J. A. M. A. **84**:16 (Jan. 3) 1925.

9. Speed, J. S.: Synovectomy of the Knee Joint, J. A. M. A. **83**:1914 (Dec. 6) 1924.

excellent results were reported. The two remaining operations were for benign tumors of the knee. The incision used was of the paramesial patellar type. Speed advised active motion with a hinged Thomas splint, beginning on the second or third day, and concluded that synovectomy is a splendid procedure, in that it offers the best results in monarticular lesions, but in the progressive stage of polyarticular arthritis it is of doubtful value. In April, 1924, Henderson [10] reported a case of synovectomy for destructive arthritis of the knee, and advised mobilization in a plaster cast for from eighteen to twenty-one days. He did not state the functional end-result, but said that pain was lost.

Nothing further appears in the literature until 1928, when Clarence Heyman [11] reported seven cases. He asserted that he believed in Swett's theory that the synovial membrane may be a source of infection, and advocated synovectomy in infectious arthritis only in the quiescent stage and after other foci have been eliminated. A split patellar incision was used. Six of the seven patients had almost a normal range of motion following the operation; the seventh lost 10 degrees of motion, which loss the author believed to be due to the fact that the disease was not quiescent in the joint.

THE SYNOVIAL MEMBRANE

The synovial membrane is a serous membrane made up of secreting cells which are loosely packed in a connective tissue structure which in turn lines a portion of the joint cavity. The synovial membrane is attached to the joint capsule on its inner sides and is reflected from the capsule over the lower surfaces to the margins of the articular cartilages. It thus forms a synovial sac within the joint, but this sac is not complete as the membrane does not cover the bearing surfaces of articular cartilage. In the loose folds of the joint capsule, the synovial membane is a thick structure which is thrown into irregular folds and which contains the nestlike collection of secreting cells which have been called synovial glands. As the membrane approaches the edges of the articular cartilage, it becomes thin, finally overlapping the margins of the cartilage slightly and being continuous with the layer of flat cells called the perichondrium which constitute the joint surface of the articular cartilage.

The function of the synovial membrane is that of supplying a lubricant to the bearing surfaces of the joint, as well as a cooling mechanism to the joint cavity. An oiling mechanism for the bearings of a joint in which friction is part of the result of activity is of great importance.

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10. Henderson, M. S.: Synovectomy for Destructive Arthritis of the Left Knee, Surg. Clin. N. Amer. **4**:565, 1924.

11. Heyman, C. H.: Synovectomy of the Knee Joint, Surg. Gynec. Obst. **46**: 127, 1928.

The result of friction is heat. It is the function of the synovial membrane to oil the joint surfaces, which it does by pouring out the synovial secretion. It is also its function to cool the joint, which it does by its excessive vascularity. The synovial membrane also contains numerous sensory nerve filaments which give to the articulations their appreciation of pain and discomfort.

Aside from these mechanical attributes which, by the way, are admirably executed by the synovial membrane as is shown by the fact that one's joints serve through long years of activity, the synovial membrane acts as a barrier to the encroachment of infection and toxic agencies. Its reaction to infection of toxic agencies is immediate and is frequently sufficient to ward off the beginning of a destructive arthritis. Synovitis is the name applied to this defensive reaction of the synovial membrane.

The synovial membrane produces a fluid which is called synovia or synovial fluid. This fluid is similar to the blood plasma and to the other serous secretions of the body. This fluid has the same value from a diagnostic standpoint as has the cerebrospinal fluid. A careful study by culture and chemical analysis will often reveal the exact cause of an obscure arthritis. Frank Fremont-Smith, Daley, Kennard and I[12] studied the synovial fluid recovered in arthritis by tapping the joint. In instances in which there was excess of fluid in a joint, the protein, chloride, sugar and nonprotein nitrogen contents were determined in the blood plasma and pathologic synovial fluids. The protein content of the synovial fluids was less than that of the plasma; the chloride content was greater than that of the plasma. This inverse relationship of protein and chloride is analogous to that found between plasma and peritoneal effusions, pleural effusions, and the cerebrospinal fluid, and is probably influenced by the Donnan membrane equilibrium. A low plasma chloride content was accompanied by a low chloride content in the synovial fluid. The nonprotein nitrogen was approximately equally distributed between plasma and synovial fluid. In fasting contents, the sugar content of noninfected synovial fluid was usually slightly lower than that of the plasma. The hyperglycemia caused by anesthesia was accompanied by a rise in sugar content of the synovial fluid. In four instances of bacterially infected fluids the sugar content was markedly lowered, while in two cases of tuberculosis of the joint the sugar content was moderately lowered. This is analogous to the low sugar content of the cerebrospinal fluid in purulent and tuberculous meningitis. Determination of the sugar content of synovial fluids may prove to be of diagnostic value.

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12. Allison, Fremont-Smith, Frank; Daley, and Kennard: J. Bone & Joint Surg. **8**:758 (Oct.) 1926.

The synovial membrane, like the peritoneum, has remarkable power of regeneration. Albert Key [13] showed in experimental animals the rapidity and assurance of this regenerative power.

The synovial membrane shows certain well recognized changes in the various forms of arthritis.

In acute arthritis due to bacterial invasion, to toxic disturbance or to acute trauma, the synovial membrane becomes acutely hemorrhagic; it thickens, pours out excess of fluid which fills the joint space and registers varying degrees of pain and loss of function in the joint. This

Fig. 1.—The line of incision in synovectomy. In the midline, above and below the patella, around the mesial border of the patella, about half an inch from its mesial border, the skin and subcutaneous tissues are divided, the quadriceps tendon is split in the line of incision and cut across near its edge just above the patella; the patellar tendon is split in midline and cut across at its mesial margin just below the patella. This incision is closed with no. 2 thirty day chromic catgut stitches in the capsule and in the quadriceps and patellar tendons. The subcutaneous tissues are brought together with no. 1 plain catgut interrupted stitches and the skin edges are approximated with interrupted silk, or with continuous locked dermal stitch.

13. Key, Albert: Reformation of Synovial Membrane in Knees of Rabbits After Synovectomy, J. Bone & Joint Surg. 7:793 (Oct.) 1925.

change in the synovial membrane may subside, leaving no trace of its presence. On the other hand, this change may progress to chronic thickening of the membrane, to proliferative changes in the membrane and to destruction of cartilage, with ankylosis as a final result. Such synovial disturbance is encountered in pyogenic infection, in the severer forms of trauma and in long continued toxic conditions.

In chronic arthritis, the changes which take place in the synovial membrane are of the greatest importance. This synovial change is that which affords the best field for the application of synovectomy.

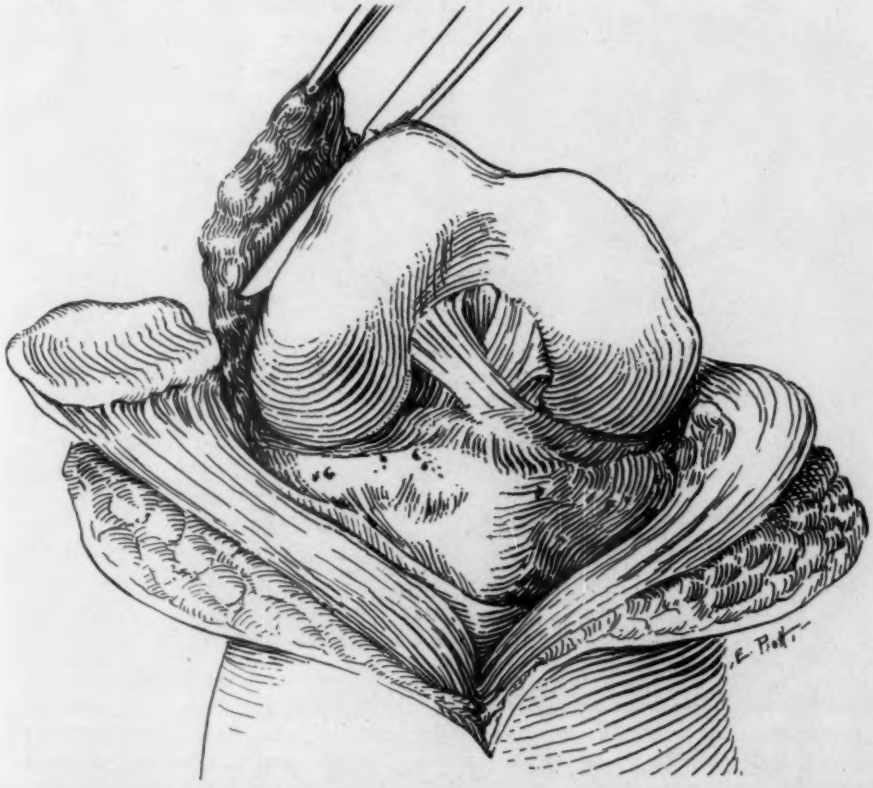

Fig. 2.—The technic of synovectomy. The patella with its tendon is retracted laterally and its articular surface is turned upward. The line of incision divides the infrapatellar fat pad in the midline. The lateral half of the fat pad is dissected free along with its synovial attachments. This mass is seized with stout clamps and carried laterally through the lateral pouch of the knee around the femur including the quadriceps pouch, and down on the inner side including the mesial pouch, thus reaching the inner half of the infrapatellar fat pad. In this way, the entire synovial lining of the joint capsule is removed. It is necessary to remove the synovial reflections from the lateral and mesial aspects of the femoral condyles and from the surfaces within the intercondylar notch. Wiping the margins of the articular cartilages and surfaces of the crucial ligaments with gauze and removing both semilunar cartilages with their synovia should also be done.

A synovial membrane which shows signs of subacute synovitis, with local tenderness, pain on movement and stiffness of the joint, and more or less excess of synovial fluid, presents the type of disturbance in which synovectomy is indicated. This is particularly true of the chronic synovial change which is the chief articular change in so-called arthritis deformans. This type of chronic multiple ankylosing arthritis is called by various names, such as "proliferative arthritis," "atrophic arthritis," "rheumatoid arthritis," "type I arthritis (Ely)" and "multiple infectious arthritis," "chronic villous arthritis" and "arthritis deformans." We have been led to believe that synovial proliferation is the chief characteristic, and we believe that the best name for this type is pro-

Fig. 3.—Operative technic of synovectomy. The knee joint is fully exposed, the patella being retracted mesially and the leg flexed on the thigh. The synovial membrane may be thus removed from the lateral pouches, from the quadriceps pouch, and from the mesial and lateral aspect of the femoral condyles. Also, it may be removed from the surfaces within the intercondylar notch. By this exposure, it is possible to remove both semilunar cartilages at the time of operation, a step which seems advisable when doing a complete synovectomy.

liferative arthritis. The synovial membrane shows marked thickening, edema and cellular proliferation, and into it are packed large masses of lymphocytes collected in foci or nests. The surface of the membrane is thickened into folds or villi which show at their margins remarkably clear collections of lymphocytes. The membrane proliferates over the margin of the articular cartilage in the form of pannus overgrowth, and the articular cartilage is destroyed. This histologic picture is characteristic.

Experience has taught that the synovial membrane should not be removed in acute pyogenic infections and in acute gonorrheal synovitis, either of the toxic type or when gonococci are found in the joint fluid. In chronic gonorrhea, with subacute synovial disturbance, the synovial membrane may well be removed.

SYNOVECTOMY OF THE KNEE

Synovectomy has been more frequently performed on the knee joint. In other joints, however, it has equal value as a surgical procedure.

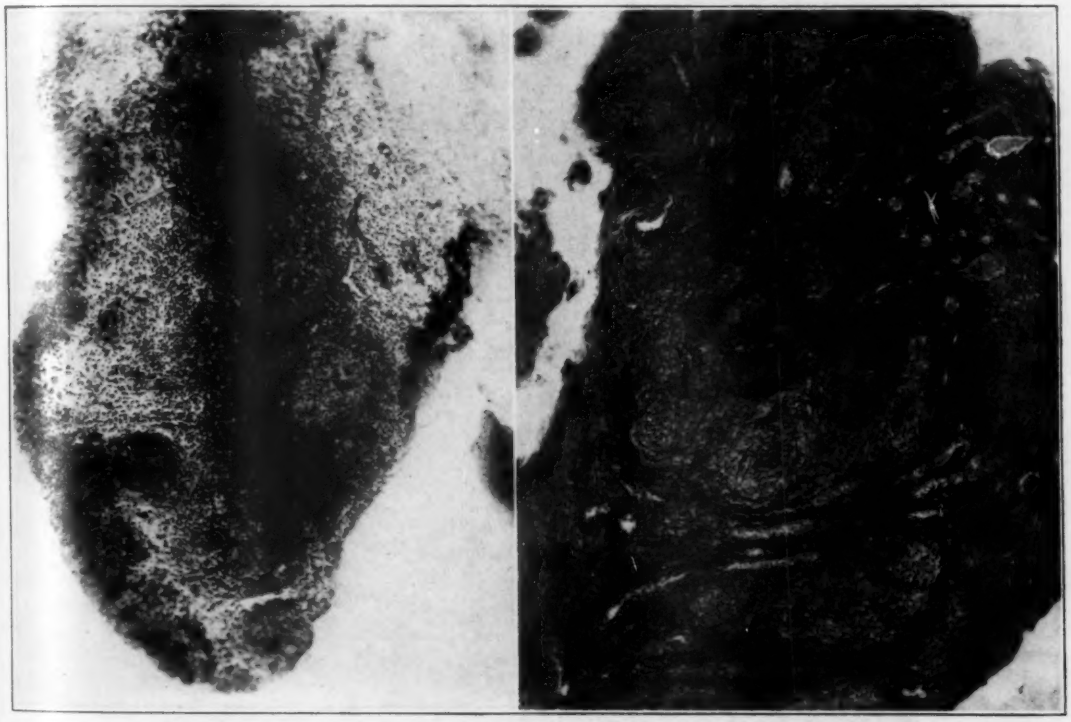

Fig. 4.—Tuberculosis of the synovial membrane. Two instances of tubercle formation in the synovial membrane. These tubercles present a characteristic picture, made up of focal collections of epithelioid cells with giant cells. Low power magnification.

Technic of Operation.—The operation is performed under general or spinal anesthesia. The limb is prepared with iodine, and a tourniquet is always used.

1. Incision is made in the midline of the extremity 4 inches above the upper border of the patella, 3 inches below its lower border. Formerly, the patella was split with a saw. At present, we have entirely abandoned splitting the patella vertically, as it is quite clear that the parapatellar incision gives equally good exposure and is much less damaging to the tissues. The vertical incision turns to the mesial border of the patella one-half inch above its upper border and follows its border at this distance to the midline, then becomes vertical again, running to

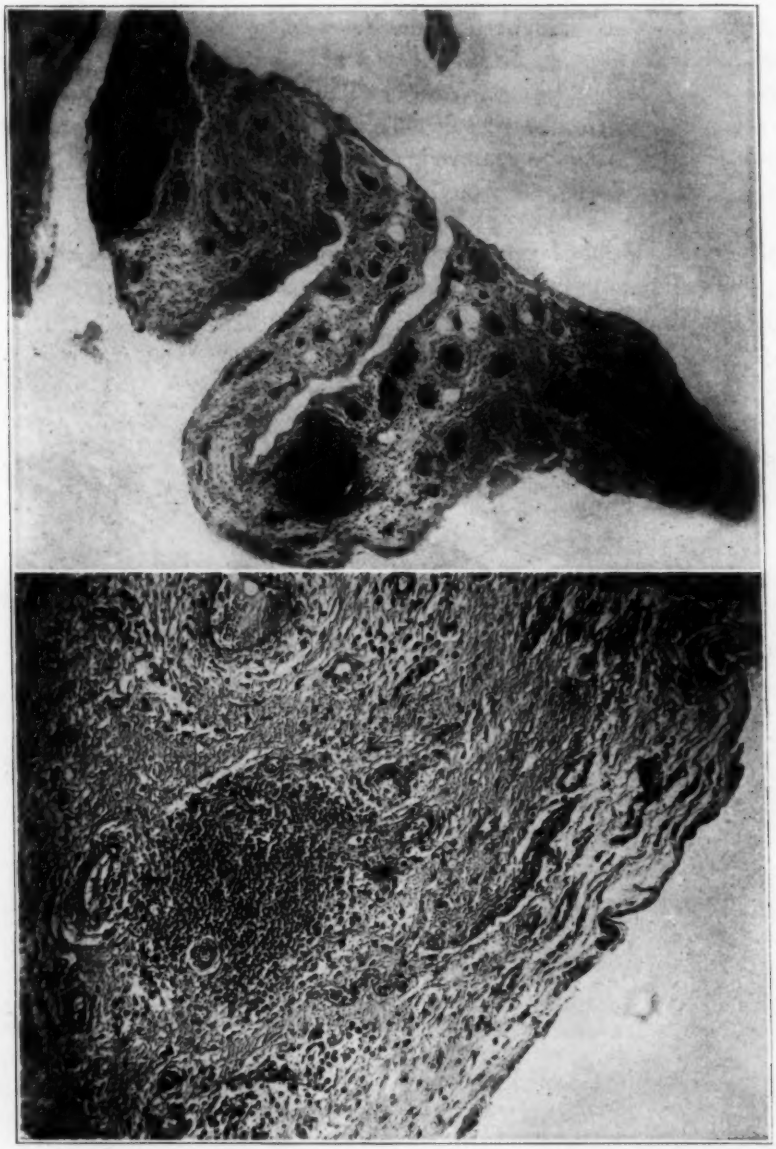

Fig. 5.—Chronic arthritis. Two instances of synovial involvement in chronic arthritis of the proliferative type. In the clinical classifications of arthritis, these joints are called by various names, such as rheumatoid arthritis, atrophic arthritis, arthritis deformans and type I arthritis (Ely). The use of the term proliferative arthritis (Nichols and Richardson) describes the process. There is marked thickening of the entire synovial membrane. It is thrown into folds or villi which show on section increased vascularity, with dilated vessels, marked infiltration with small round cells, and a definite tendency of these lymphocytes to collect in foci. This focal arrangement of the lymphocytes is characteristic of this type of arthritis.

the tubercle of the tibia. The skin is divided in this line, skin towels are clamped in place; a clean knife is selected; the operating team washes its gloves in alcohol, and the joint capsule is incised in the same line.

2. In opening the joint, in many instances it is possible to separate the synovial membrane from the capsule along the line of incision. Below the patella the incision will divide one corner of the patellar tendon and also divide the infrapatellar fat pad in the midline.

The synovial membrane is now divided in the line of incision throughout its length. The patella is seized with holding forceps at its capsular margin and is turned over the joint surface upward lateral to the femoral condyle. The anterior

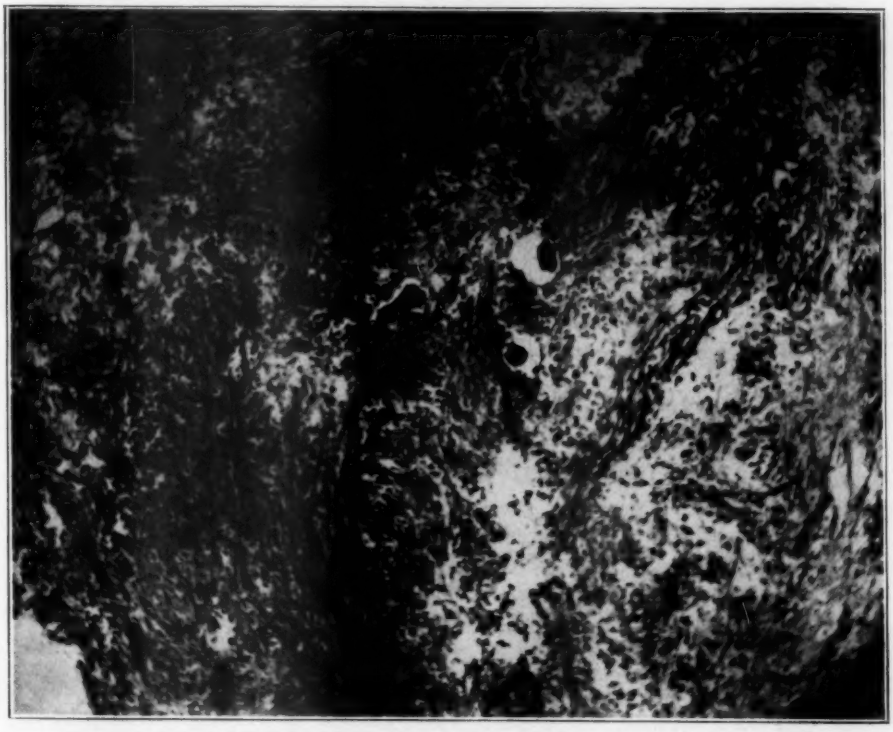

Fig. 6.—Benign giant cell tumor of the synovial membrane. Following the injection of an irritant into the joint cavity (a solution of formaldehyde), the entire synovial membrane became a tumor mass.

compartment of the knee joint is then exposed. The disordered state of the synovial membrane is now visible.

3. The knee is flexed to a right angle, and the tibial head, the crucial ligaments, the intercondylar notch and the semilunar cartilages may now be thoroughly inspected.

4. This step consists of removal of the synovial membrane—synovectomy.

Beginning at the midline division of the infrapatellar fat pad, the lateral half of the fat pad is seized with heavy clamps and the synovial membrane is dissected from the inner surface of the patellar tendon and head of the tibia. The external

semilunar cartilage may be removed entire or left in situ. The lateral pouch of the joint is freed of synovial membrane up to the border of the patella, and the lateral aspect of the femoral condyle is also cleared. While the operator holds to this mass of synovial membrane, the suprapatellar pouch is carefully freed of its synovial lining, and the dissection comes over the femur to the mesial pouch of the joint. The internal semilunar cartilage may be removed or left in place. The removal ends with the inner half of the infrapatellar fat pad. The space between the femoral condyles and the two crucial ligaments is now cleared of synovial membrane.

5. The margins of the articular cartilages where pannus growth has established itself are wiped clean with gauze, more or less damaged cartilage being exposed.

Fig. 7.—Two instances of involvement of the knee joint in which synovectomy was performed. The knees are swollen, boggy and painful on motion. There is marked thickening of the synovial membrane, sometimes described as "atrophic arthritis," "rheumatoid arthritis" or "chronic infectious arthritis." In each instance synovectomy was done, with entire relief from symptoms and with good return of function. The section of the synovial membrane revealed the characteristic picture of proliferative arthritis (see fig. 4).

The entire joint cavity is carefully wiped with gauze to remove loose vestiges of synovial membrane.

6. The knee is closed by interrupted suture of the quadriceps and patellar tendon and the capsule about the margin of the patella. We have habitually used no. 2 chromatized catgut. The subcutaneous tissues are approximated by interrupted sutures of no. 1 plain catgut. The skin is closed with silk or dermal continuous stitch. A firm dressing and bandage are applied, and the tourniquet is removed.

7. The knee should be kept at rest for from twenty-four to forty-eight hours and supported in suspension slings. The patient should be encouraged to move the joint. Active motion should be encouraged early but never passive motion of any kind. A Thomas splint with Peirson attachment is a convenient form of support.

8. Until the healing of the skin wound is complete and the stitches are removed, nothing strenuous in the way of exercise should be used, except daily exercises for

the quadriceps extensor. The patient should be taught and encouraged in the setting of the quadriceps femoris muscle, and should perform the exercise many times each day. As soon as the wound is healed, the patient should be up in a wheelchair, should have crutches, and should make as much progress each day toward movement of the joint and weight bearing as is possible. Pain should be avoided. We have found that most of our patients regain considerable motion within three weeks. In several instances when there was delay at early movement, we have found it necessary later to flex the knee gently under an anesthetic.

9. After-care consists of heat, massage and exercise. Functional use should be attempted as soon and as much as possible.

10. Our experience justifies the recommendation that at the time of synovectomy the semilunar cartilages be removed.

Long since we have given up the use of plaster-of-Paris and all forms of stiff splints.

Fig. 8.—After-treatment in synovectomy. Use of the Thomas splint with Peirson attachment. The extremity is suspended so that its weight is counterbalanced. The patient has control of the Peirson attachment with the weight which is in her hand. Early motion of the joint which has been operated on may be encouraged.

SYNOVECTOMY OF OTHER JOINTS

In several instances of chronic multiple arthritis, synovectomies have been performed on other articulations. The wrist joint is often affected and offers a suitable field for synovial removal.

It seems feasible to recommend synovectomy in the proliferative type of arthritis as soon and as extensively as possible. The marked improvement in general well-being and in symptoms both in the joint operated on and in other joints seems to indicate definitely that the synovial membrane bears more than a secondary relationship to the disturbance in the joint. Indeed, we are inclined to believe that this type of arthritis is primarily a synovial disease. Furthermore, once established in the synovial membrane, it has, as Swett has suggested, the potency of an original focus of toxic or bacterial influence on the other articulations.

CONTRAINDICATIONS TO SYNOVECTOMY

It seems to us that there are few contraindications to the removal of the synovial membrane in the chronic proliferative type of arthritis. Pain and discomfort are greatly relieved; functions are improved, and the patient usually shows marked improvement in the other joints which are involved. Therefore, age, general physical condition, hopeless inactivity, etc., are not contraindications. We have operated on several persons who had been bedridden and chairridden for years, whose general health was below par and who seemed to present every reason for nonintervention. We found that they tolerated the operation well, improved in every way and were finally able to walk.

Fig. 9.—After-treatment in synovectomy. Method of suspending the extremity after synovectomy. The supporting slings are made of saddle felt, and the weight of the extremity is counterbalanced so that the patient may move the knee joint.

Joints affected with acute pyogenesis and acute gonorrhea should not be synovectomized; ankylosis is perhaps hastened.

The tuberculous joint should not be synovectomized alone; synovectomy in conjunction with bony fusion is indicated in tuberculosis of the joints.

Joints affected with chronic quiescent gonorrhea recover good function without pain or disability after synovectomy.

Our experience with synovectomy has been as follows: From October, 1923, to October, 1928, fifty synovectomies have been done in the Orthopaedic Service of the Massachusetts General Hospital. In practically all of the cases the same operative technic was used, which consisted of a paramesial patellar incision, dislocation and retraction of

the patella outward, with complete removal of the synovia. The best exposure is obtained with the knee completely flexed. In four recent cases, both semilunar cartilages were removed. The general routine of after-treatment has been to start active motion on the second or third day, the knee being suspended in balanced slings or a Thomas splint with Peirson attachment. Weight-bearing was usually allowed at the end of a week to ten days with crutches, and in a few instances weight-bearing was begun on the fifth day after operation. The guide to the extent of motion to be encouraged as well as the time to allow weight-bearing is the presence of pain and discomfort. We have cautioned these patients to avoid movement or attempted function which causes pain in the joint.

Double synovectomies were performed in three cases; that is, the synovial membrane was removed from both knees at separate operations, several months apart.

Diagnosis in Fifty Cases

Chronic infectious arthritis	27	(of this number 19 had multiple involvement of the joints; 8 were monarticular)
Gonorrheal arthritis	4	
Tuberculous arthritis	6	
Hypertrophic arthritis	5	
Osteochondritis dissecans	2	
Charcot joint	1	
Giant cell tumor	1	
Internal derangement	1	(with hypertrophy of the synovia)
Atrophic or so-called hypertrophic villous arthritis	3	

Three patients died of other diseases after leaving the hospital
In five cases, the patients could not be traced
Forty-two cases were available for studies of end-results

The fifty cases were subdivided as to diagnosis, as shown in the accompanying table.

It is interesting to note that there was one case classified before operation as chronic infectious arthritis in which microscopic sections and inoculation into guinea-pigs showed the presence of tuberculosis.

One patient died of sepsis following operation.

Three cases resulted in fusion of the knee joint.

There were four cases of gonorrheal arthritis of the knee in which synovectomy was done; two of these resulted in fusion; the result in one was unknown, and the fourth showed 90 degrees painless function and complete extension one year following operation.

There were four cases of tuberculosis of the knee, in all of which synovectomy was done as a preliminary step to operative fusion.

Three cases of the chronic infectious arthritis ended in fusion with painless weight-bearing function.

In this series there were eighteen males and thirty-two females; the youngest patient was 15 and the oldest 65 years.

A study of the cases showed that more than 95 per cent of the patients were relieved of pain by the operation. In only two cases was there a recurrence of pain: in the first, this occurred three months following operation; in the second, almost a year elapsed after operation before the reappearance of pain.

It was found that the average motion following operation was about equal to or slightly less than that present before operation. If there was flexion of 90 degrees, the result was found to be satisfactory from the patient's point of view. In patients with less than 90 degrees of flexion, some difficulty was experienced in going up and down stairs.

In the whole series, the average period of time before return to work (part time) was six months, and from ten months to one year for full-time work. More than 75 per cent were able to go back to their original work; five patients who had been complete economic losses for

Fig. 10.—Synovectomy performed on the right knee. Range of motion accomplished without difficulty by the patient three weeks after operation.

from one to one and a half years prior to operation returned to their original occupation after operation.

From the patient's point of view, the results were satisfactory in all but three cases: two of these patients stated that their knees were no better than before the operation; one patient stated that he was worse than before the operation. Following operation, one of the patients had relief from pain lasting about three months. In a fourth case relief from pain lasted one year, when a recurrence of all the original symptoms developed, and it was necessary to do a second synovectomy; at the second operation, it was found that there had been a complete regeneration of the synovia. The appearance at operation was much the same as at the time of the first operation. There can be little doubt of the fact that synovia regenerates. Until the work of Key and Wolcott,[14]

14. Key, A.: J. Bone & Joint Surg. **7**:793, 1925. Wolcott: J. Bone & Joint Surg. **9**:67, 1927.

there was some doubt about the manner in which this regeneration occurred. Key, working with dogs, showed decisively that this regeneration occurs from metaplasia of the connective tissue cells, and that it is possible in the dog for the complete restoration of a normal appearing and functioning synovia.

In the multiple infectious arthritis group in which both knees were affected and one knee only was operated on, all the patients but one stated that the knee operated on was less painful than the knee not operated on. This one case was classified as an unsatisfactory result, and later came to operative fusion.

It is difficult to estimate the effect on the patient's general condition. From a study of these cases, more than 65 per cent of the patients reported improvement in their general condition; whether this was due to actual removal of the source of infection or of the improved physical function of the patient as a result of exercise and freedom from pain it is difficult to estimate, since many cases of arthritis show periods of improvement.

From the surgeon's point of view, the operation seems to be satisfactory. Ninety per cent or more of the patients are relieved of pain, and a great many who had been incapacitated before operation are able to return to work. Function in the joint is not decreased. Alinement and weight-bearing are usually improved.

From a study of these cases, one has a right to expect at least as much motion after operation as was present before operation; 90 per cent showed as much motion as before operation; 5 per cent showed gain, and 5 per cent loss. It is interesting to note that in the small series of four cases of gonorrheal arthritis, 50 per cent resulted in fusion, and pain was not relieved in any case.

From a limited series (four cases), removal of both semilunar cartilages seems to improve the comfort and function of the knee after operation.

SUMMARY AND CONCLUSIONS

1. Synovectomy is a useful operation in properly selected cases in polyarticular as well as in monarticular arthritis.

2. In practically all cases, it relieves pain and enables the patient to resume weight-bearing.

3. Of the series here reported, 65 per cent showed marked improvement in general health.

4. There is evidence to show that removal of both semilunar cartilages in a complete synovectomy improves the function and gives greater relief from pain.

5. Synovectomy is contraindicated in acute gonorrheal arthritis, but has value in the chronic subacute stage of gonorrheal arthritis.

6. The improvement which is noted immediately after operation in cases of multiple proliferative arthritis is most striking. The explanation for this is doubtful. It has long been observed that these patients show marked lessening of symptoms in the joints after the administration of a general anesthetic or after protein shock. After synovectomy, all the involved joints are less painful and less swollen, and it has seemed to us that in the foregoing series a large percentage of this improvement has remained.

A METHOD OF RECONSTRUCTING A VOLUNTARY SPHINCTER ANI*

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Defective function of the sphincter ani is associated with great inconvenience for the patient and for those about him. It is not surprising, therefore, that numerous operative procedures have been suggested for the purpose of making a more or less firm closure of the lower end of the rectum when the sphincteric action is not perfect. The methods which have been most widely applied are: torsion of the lower end of the rectum according to the method of Gersuny or the replacing of the defective sphincter by a ring formed from the fascia lata according to the method of Thiersch.

An important and general defect, however, is common to all these closures; their activity is limited by the elasticity of the tissues of which they are formed. Active dilatation and contraction under the control of voluntary impulses are also impossible, thus there is not sufficient elastic contraction of the lower end of the rectum to retain gaseous and liquid feces. The generally accepted degree of contraction which allows easy introduction of the index finger into the rectum insures the retention of solid feces, but not of gaseous and liquid feces. A smaller opening either causes the patient to suffer from difficult defecation or destroys the closure owing to the pressure of the solid fecal masses during their passage.

All these considerations led me to attempt the restoration of a voluntary sphincter ani.

REPORT OF A CASE

A man, aged 28, entered Engel's Hospital in September, 1926. He complained of incontinence of gas and feces. He was born with an atresia ani, and subsequent to the primary operation had repeatedly been subjected to various methods of surgical intervention for incontinence. The last operation consisted of the formation of a firm annular closure out of the fascia lata; the resistance of the latter, however, was soon overcome. Since then an intolerable condition of incontinence had again developed, so that the patient consented to any kind of surgical intervention.

The operation was performed under general anesthesia. The method of procedure was as follows:

1. The patient was placed in a position similar to that used during hemorrhoidectomy, his legs being fixed by means of a leg-holder.

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* Submitted for publication, Nov. 15, 1928.

* Translated by I. R. Guerbatch.

2. Two vertical incisions were made on the right and on the left of the anal orifice, occupying the central part of the space between the anus and the tubera ischii; these incisions penetrated to the aponeurosis, covering the muscles of the perineum.

3. The fasciculi of the glutei maximi were then denuded by means of two crescent-shaped incisions with their convexity directed laterally and posteriorily. These were made behind the tubera ischii.

4. The fascia lata was then exposed through an incision 20 cm. long on the external surface of the femur. Two strips, each 18 cm. long and 2 cm. wide, were formed of the fascia lata.

5. Two forceps were then drawn transversely through each of the vertical incisions of the perineum anteriorly and posteriorly to the anal orifice. One pair

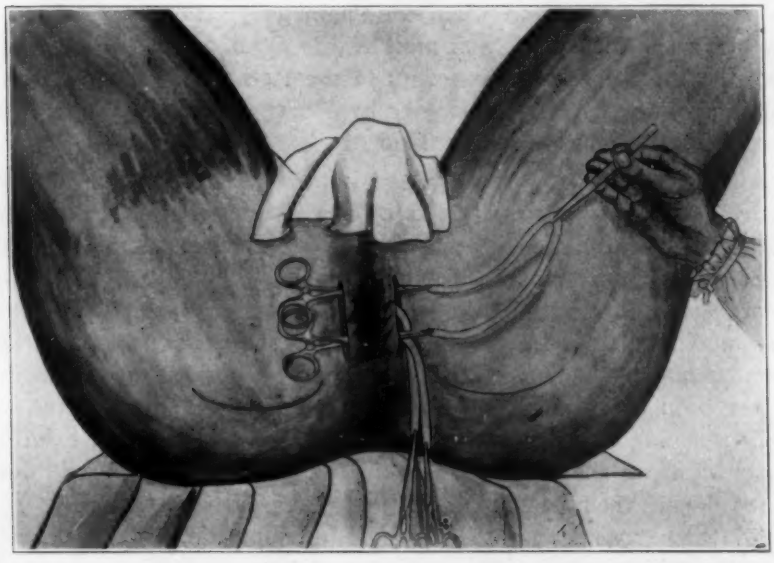

Fig. 1.—This and the following illustrations depict the operative procedure.

of forceps was directed from right to left, the other from left to right, both passing through the subcutaneous tissue (fig. 1).

6. The ends of the fascial strip, caught by means of the two forceps on the right of the anal orifice, were drawn through the left vertical incision; the other fascial strip was drawn by means of the other two forceps in the opposite direction. As a result, the lower end of the rectum was encircled by two fascial loops.

7. Two forceps were then introduced through each of the crescent-shaped incisions into the vertical incisions on the same side, one of them being drawn above the fasciculi of the glutei maximi, the other under them (fig. 2).

8. The ends of the fascial loops were then caught by means of the forceps and drawn through the crescent-shaped incisions, where they were placed one on the other in a condition of slight tension and then fixed by means of a series of catgut sutures (fig. 3).

Figure 2

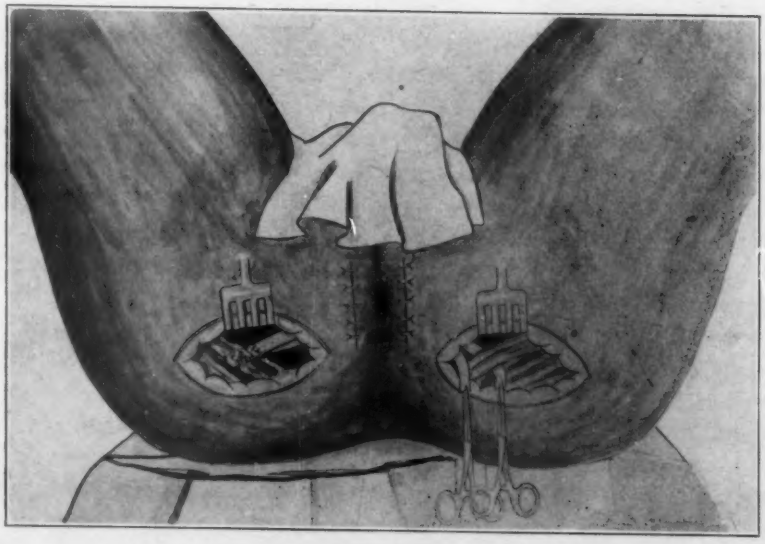

Figure 3

9. Cutaneous incisions were sutured with silk.

10. Defecation was delayed for ten days by the administration of opium.

Postoperative recovery took place without complications, and at present, ten months after the operation, the patient is able to retain not only feces, but gas. The index finger introduced into the rectum experiences a sensation of pressure when the glutei maximi are alternately contracted and relaxed as by the contraction of a normal sphincter ani.

I do not, of course, presume to draw unwarranted conclusions from this single case. My purpose is to acquaint my colleagues who have similar cases with a method which apparently gives one reason to hope for favorable results in the future.

PLASTIC OPERATION FOR ANAL INCONTINENCE*

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Loss of control of the anal sphincter may result from distant lesions, chiefly involving the central nervous system and resulting in paralysis, or from local injuries to the muscle itself or to the nerves entering it. Of the second group of cases perhaps a majority are due to surgical operations, often undertaken with clear knowledge that incontinence may result, but nevertheless necessary. The condition is most distressing. It is frequently associated with a greater or less degree of prolapse of the rectal mucosa. Incontinence may be partial or complete. Often with a high degree of incontinence and marked prolapse the patient not only is unfitted for any form of social life, but is so uncomfortable physically as to be actually bedridden.

A number of methods have been described for the treatment of anal incontinence. I have tried most of them, from simple suture of the remnants of the damaged muscle to elaborate plastic operations with strips from the muscle margin of the gluteus maximus muscle. The experience has been uniformly disappointing. In 1925, the idea was conceived of making use of the preserved fascia of Koontz. This was utilized in two cases as a subcutaneous purse-string suture about the anal canal, introduced through two small incisions at the anterior and posterior commissures. The incisions were connected with each other by subcutaneous blunt dissection; the strip of fascia was threaded through the tunnels thus formed, and drawn up snugly and fastened. In both cases the fascia healed in, in spite of a thin serous drainage for several days. The results showed some improvement and both patients felt gratified, but much was left to be desired. As a matter of fact, improvement of actual control could not be claimed. What had been done was to tighten up a patulous outlet, give a feeling of greater perineal firmness and stop eversion of anal mucosa, but increased power of voluntary contraction was not found, nor could it have been expected.

In the summer of 1927, I received from a friend in Russia the manuscript of an article by Prof. R. R. Wreden,[1] of the Leningrad Medical Institute, entitled "A Method of Reconstructing a Voluntary Sphincter Ani." It employed a principle, as far as I know, entirely original, which at once made the impression of being a valuable addition to the methods of attack on anal incontinence. Furthermore, Pro-

* Submitted for publication, Nov. 1, 1928.

* From the Department of Surgery, Johns Hopkins University School of Medicine.

1. Wreden, R. R.: A Method of Reconstructing a Voluntary Sphincter Ani, Arch. Surg., this issue, p. 841.

fessor Wreden reported having used the operation successfully in one case. The principle consists in slinging two loops of fascia subcutaneously from the gluteus maximus muscles; they pass around the side of the anus opposite the gluteus maximus from which they start and, since they interlock with each other, thus enclose the anal outlet in a ring of fascia. This ring can be tightened by the contractions of the glutei, drawing the loops of fascia tight. Professor Wreden utilized strips of the patient's own fascia lata for the formation of the loops.

Since reading Professor Wreden's article, I have had two patients with seriously damaged sphincter ani muscles, and have employed the principle briefly outlined with results that will be reported in detail

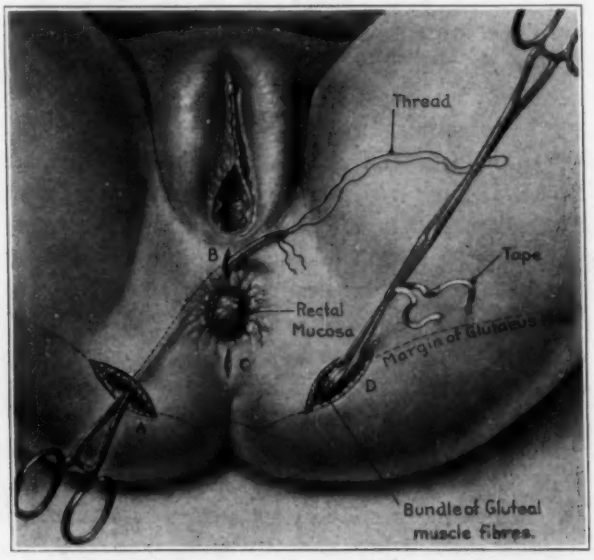

Fig. 1.—*A* and *D* indicate the incision to expose the margins of the glutei muscles. A bundle of muscle fibers from the edge of the gluteus is shown drawn up with a loop of tape in incision *D*. *B* and *C* indicate incisions to permit subcutaneous passage of fascia strips about the anal canal.

below. The actual operative steps are somewhat different from those described by Wreden, and instead of the patient's own fascia, strips of Koontz' prepared fascia were used. This was done to avoid the additional operation on the thigh. It is possible that in case 2 better healing might have resulted if autogenous fascia had been used. The steps of the operation are as follows:

METHODS

The patient is placed in the exaggerated lithotomy position and the usual preparation of the field carried out. Four separate incisions are made (fig. 1). Two of these are symmetrically placed on either side, along a line from the coccyx

to the tuberosity of the ischium. They are about 3 or 4 cm. long and are carried through the fat deep enough to expose the mesial margin of the gluteus maximus muscle. From this margin of the muscle a substantial bundle of fibers, as thick as one's index finger is bluntly separated in the long axis of the fibers, but not detached, so that it forms a band of muscle about which the fascia loops are later to be passed. The other two incisions are short, deep stab-wounds in the midline just in front of and behind the anus, 1 cm. from the mucocutaneous margin. Then by blunt dissection each lateral incision is connected subcutaneously with both the anterior and the posterior stab-wounds, and these two stab-wounds are connected with each other by blunt subcutaneous dissection around each side of the anal

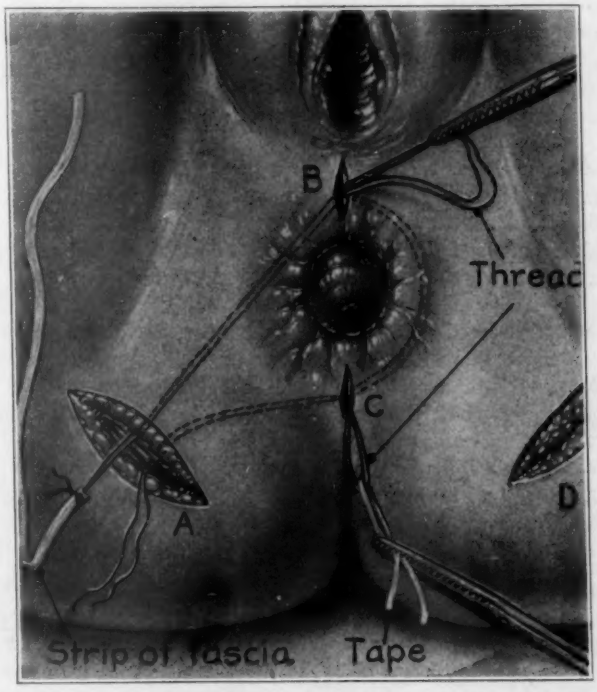

Fig. 2.—Subcutaneous dissection completed for one side, with guide thread in place, running from *A* to *B*, to *C* and back to *A*. Loops of redundant thread are left projecting from incision *B* and *C* to facilitate pulling through of fascia, shown tied to end of guide thread.

canal. The dissection is simply done by pushing a closed curved clamp or similar instrument through the fat in the desired direction. Through the tunnels thus formed two strong linen threads are pulled, as shown in figure 2. Each thread starts from one of the lateral incisions, encircles the loosened strip of gluteus muscle, passes to the anterior midline incision, where a loop of it is pulled out, and then around the opposite side of the anal canal through the subcutaneous tunnel to the posterior midline incision. Here, again, a loop of the thread is pulled out. Then back again it goes subcutaneously to the lateral incision from which the start was made, but this time not passing around the band of gluteus maximus. To the end of the linen threads are firmly tied the strips of fascia to be used.

These should be at least 20 cm. long and about 1 cm. wide. The linen threads are then used as guides and tractors to pull the fascia strips through the same subcutaneous channels that they themselves have followed. The purpose in leaving a loop of slack in the linen threads at the midline incisions is to facilitate this pulling through process. The loop at the anterior incision is steadily and firmly pulled on until the fascia is drawn into the lateral incision, around the bundle of gluteus maximus and through the subcutaneous tract and appears at the anterior midline incision. It is drawn out of this incision until about 8 or 10 cm. of fascia protrudes through it. The loop of thread at the posterior incision is pulled on, making the attached end of fascial strip reenter the anterior incision and pass subcutaneously around the anal canal on the side opposite the lateral incision from which it started. It is then pulled out of the posterior incision until all slack in the fascia strip is drawn taut. Then the linen thread emerging from the original lateral incision is pulled on till the fascia is drawn out through the wound where it entered and its two ends are finally clipped together with a clamp. The opposite side is treated in the same manner. Figure 2 makes this procedure clearer than the verbal description.

At this stage of the operation, two loops of fascia are placed subcutaneously so that they encircle at one end the anal canal and at the other end a band of gluteus muscle, and interlock with each other about the anal canal. The two ends of each strip protrude from the same lateral incision. All that remains is to tighten the loops about the anal canal by tying the two corresponding ends of each strip to each other. The knot can be made in any way that the surgeon desires, and may if desired be further fixed by a transfixing suture. The degree of tension desired in tightening the loops must be left to individual judgment, but as there may be some tendency to relaxation later it would be wise to close the anal outlet quite snugly. The way in which tightening the fascia loops contracts a patulous anus is quite striking. After the loop ends have been fastened to each other securely, any excessive length of fascia strip is cut away; the knotted ends are dropped back deep in the lateral incisions and all incisions closed with a few interrupted sutures, without drainage. Figure 3 shows the complete operation.

REPORT OF CASES

Case 1.—As a result of a surgical operation on the rectum which was followed by some postoperative bleeding and packing of the wound, a woman, aged 65, had almost completely lost the control of the muscles of the sphincter ani. This condition had persisted for several months and did not show a tendency toward improvement. On the contrary, the patient's condition was getting slowly worse. She would have involuntary bowel movements at frequent intervals whenever she was up and about, which made it necessary to wear a pad at all times and completely prevented either social or domestic activity. As a matter of fact, for a good while the patient had confined herself largely to her own room because of this condition. In addition to the incontinence described there was a partial prolapse of the rectal mucous membrane when the patient stood. This added considerably to her discomfort.

The operation already described was performed at the Union Memorial Hospital on Feb. 4, 1928, with the patient under ethylene gas. The details of the operation will not be repeated here. Following the operation, the patient made a slow but progressive recovery. It was some time before she regained her general strength, and it was at least three weeks before conclusive evidence of sphincter control could be recognized. The wounds all did well except the right lateral

incision, which discharged a thin serous drainage for perhaps five or six weeks and from which was discharged a small shred of fascia a few millimeters long and not any thicker than a piece of fine silk. Otherwise, the fascia healed in completely and months afterward could be plainly felt lying in its subcutaneous bed. The question of return of control was interesting. The bowels were purposely kept closed by medication for eight or nine days following the operation. When the first movement took place, the patient had scarcely more control than before the operation. She was greatly disappointed, and I was in doubt until it was recognized that the whole success of the operation depended on training the patient to use the glutei muscles voluntarily as a method of tightening the anal outlet. This was explained to the patient, who was intelligent and cooperative and eager

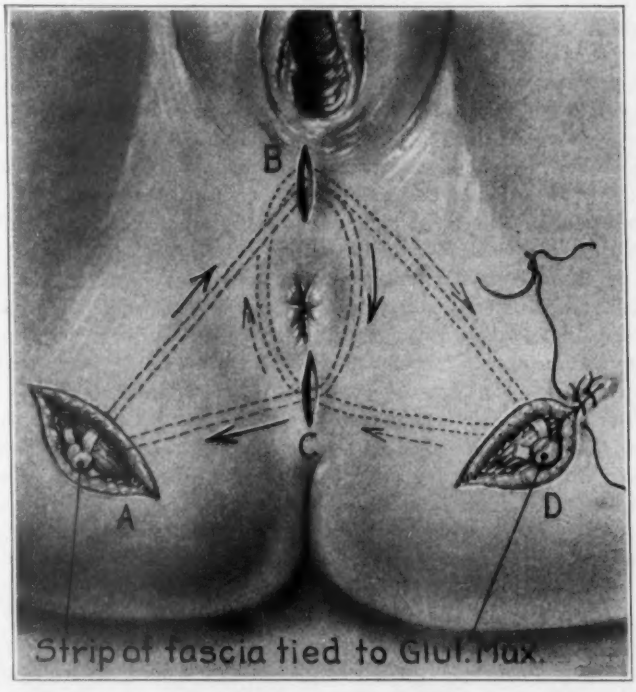

Fig. 3.—Both strips of fascia in place in subcutaneous tunnels, as shown by double dotted lines. The ends of the fascia strips are pulled taut, closing the anus, and are fastened with a knot about the bundle of gluteus fibers. Beginning closure of the small wounds.

to get well. The result of this new point of view was immediately apparent. By voluntarily tensing the glutei muscles, the patient was able to shut off the anal canal almost completely. With continued practice this habit became established, and ten weeks after the operation the patient was able to walk long distances and to ride in an automobile for an hour or more without discomfort from prolapse or loss of sphincter control. As a matter of fact, after the first few weeks, accidental escape of gas or feces became rare.

The patient was seen in May, 1928, about four months after the operation. At that time she herself felt that the success of the operation was almost complete,

and the result of examination was gratifying. All of the wounds were healed, with small, healthy, firm scars. The fascia was definitely in place and working. When the patient contracted the glutei muscles, the two loops of fascia snugly closed the anal canal. The patient had been able to resume her former activities almost entirely, going to the theater, taking drives and doing anything she wished within the limits of her general physical strength. She still tired easily and could not carry on beyond a certain length of time without exhaustion. She was not, however, hampered by either prolapse or incontinence. To me, this result seemed by far the best that I had ever seen as a result of attempts to cure loss of sphincter control.

Case 2.—A white woman, aged 60, had a past history that is too extensive to narrate here in detail. It involved altogether twenty-seven different operations, most of which had been done about the rectum and the anus. The history dated back twenty years, at which time operation for supposed rectal tuberculosis had been done during the course of which the sphincter muscle had been removed. Following this a number of attempts had been made to improve the condition of the anal outlet, some of them having been done by the most distinguished surgeons in the United States. The results had been uniformly unsuccessful. At the time that I first saw the patient on March 5, 1928, her condition was just like that of the first patient described except that probably she suffered more extremely. The prolapse in this case was large, a mass eversion of rectal mucous membrane as large as a good sized peach taking place whenever the patient stood up, strained or made any movement that increased the abdominal pressure. This gave her a great deal of pain, and there was a constant mucous discharge. The circumference of the anus was a mass of broad and deep scar tissue, the result of various surgical procedures. No trace of a sphincter muscle could be recognized, and the patient did not have the slightest ability to contract on the examining finger.

The operation previously described was done in this case also, on April 10, 1928, at the Union Memorial Hospital under ethylene gas. Unfortunately, the outcome in this case was entirely different from that of the first patient. The postoperative convalescence was fairly satisfactory for the first two weeks. During this time the prolapse did not occur, and there was definite beginning control by the contraction of the glutei muscles. It became apparent that at about this time one of the strips of fascia was not going to heal in. Signs of infection appeared about the incision through which this strip of fascia had been introduced. The wound was opened and definite pus escaped; a short time afterward good sized masses of dead fascia strip were discharged from this wound. It was evident three weeks after the operation that the whole strip had been disintegrated, and most of it had been discharged. About this time the second strip showed the same process. The incision in the skin had to be opened, pus escaped and fragments of tissue also were discharged. The wounds continued to drain for a number of days longer and did not heal until all the fascia had disappeared from the wounds. As soon as the fascia strips commenced to disintegrate the prolapse began to return, and by the time that they had dissolved completely the patient's condition, as far as the rectal outlet was concerned, had reverted completely to what it was before operation. In other words, this operation was a total failure, owing to the infection of the wounds and the subsequent discharge from them of the fascia strips. The patient has been told that if she is willing to attempt another cure of her condition that the operation might be repeated, a strip of her own fascia being used, with perhaps somewhat better chances of success.

COMMENT

The objection may be made against the use of prepared strips of dead fascia that they might provoke more chemical reaction in the tissues than would be the case with autogenous fascia strips. In a region like that about the rectum in which infection is an ever present possibility, the occurrence of a chemical reaction around the fascia strips might add to the chances of infection taking place.

SUPPURATIVE PERICARDITIS

REPORT OF TWO CASES DRAINED BY THE POSTERIOR ROUTE *

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The subject of suppurative pericarditis has been thoroughly presented, the literature reviewed, and records brought up to date in the recent papers of Peterson,[1] Winslow and Shipley,[2] and Williamson.[3] Including the following reports, there are now 133 cases on record in which operation has been performed. Many unreported cases undoubtedly exist. In the discussion which followed the presentation of Peterson's paper before the Congress of Thoracic Surgeons in New York, the possibility of a posterior approach for drainage of the pericardium was mentioned. To demonstrate the plausibility of this method of approach in certain instances, the following cases are recorded.

REPORT OF CASES

CASE 1.—*History.*—Sun Chan Chun, a Chinese soldier, aged 19, was admitted to the surgical service of the Peking Union Medical College on Dec. 17, 1925, four days after having been shot in the left axilla. The missile, a rifle bullet, was retained, and the roentgenologic examination at the base hospital at Nan Yuan, before admission, showed it to be lodged behind the left tenth rib in the posterior axillary line. There had been considerable hemoptysis following the injury, but for several days prior to admission there was only blood-tinged sputum. He had an increasing dyspnea.

Examination.—The patient was a small youth in marked respiratory distress. He was cyanotic. On admission, the temperature was 39.6 C. (103.3 F.); respirations, 36, and the pulse rate, 120. The blood pressure was 90 systolic and 70 diastolic. There was a small, clean and dry perforating wound in the left midaxillary line at the sixth interspace. The heart was pushed markedly to the right. Its impulse was felt 1 cm. from the midclavicular line in the fourth interspace, where there was also the right border of dulness. The left border of dulness could not be determined because of flatness at the base of the left lung. The cardiac sounds were clearly heard to the right of the sternum, but were distant on the left side. There were no murmurs. The rhythm was regular. The bases of both lungs were dull. On the left side, there was flatness up to the angle of the scapula. There were coarse ronchi throughout the chest, and fine moist râles at the base of the

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* From the Department of Surgery, Peking Union Medical College.

1. Peterson, E.: Suppurative Pericarditis: Report of Three Cases, Arch. Surg. **16**:366 (Jan.) 1928.

2. Winslow, N., and Shipley, A. M.: Pericardiotomy for Pyopericardium: A Review of the Literature to May, 1927, and Report of Ten New Cases, Arch. Surg. **15**:317 (Sept.) 1927.

3. Williamson, E. G.: Ann. Surg. **85**:659, 1927.

right lung. The voice sounds were suppressed over the base of the left lung and amphoric above, and tactile fremitus was not elicited over the base. The percussion note was hyperresonant over the apex. The diagnosis on admission was: gunshot wound of the left side of the chest and lung, with hemothorax or pyohemothorax, and displacement of the heart to the right.

Examination by the medical service on the day following admission confirmed this diagnosis, and thoracentesis was advised to relieve the mediastinal pressure. Two unsuccessful attempts were made with an exploring needle to find fluid. Roentgen examination showed that the heart and trachea were pushed far to the right. On the left there was a large, dense, rounded shadow. The costophrenic

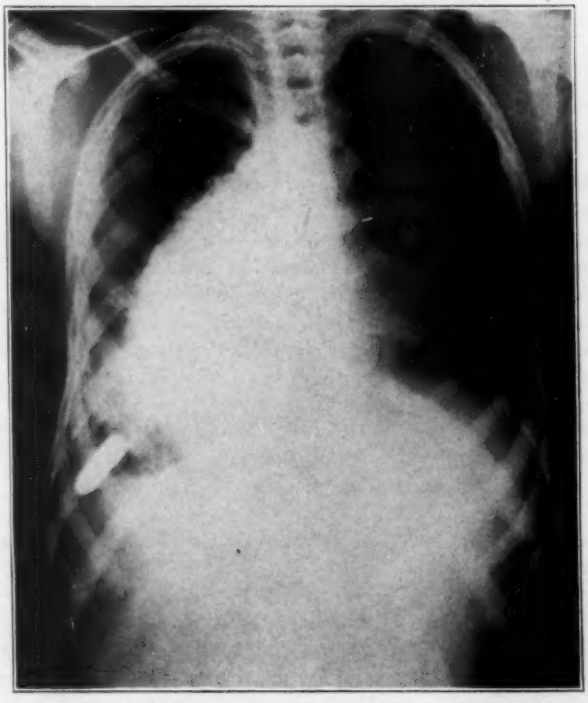

Fig. 1 (case 1).—Roentgenogram of the chest on admission to the hospital, Dec. 17, 1925.

angle was clouded. A rifle bullet lay just within and parallel to the tenth rib in the midaxillary line. The diagnosis of pericarditis with effusion, left hemothorax and retained foreign body was made (fig. 1). The same evening a pericardiocentesis was done by Dr. Kwan. The puncture was made in the fourth left interspace next to the sternum, and 100 cc. of a yellow turbid fluid was withdrawn. Smears showed gram-negative and gram-positive cocci in short chains. Cultures failed to show growth of the organisms.

The next day, December 19, the patient felt subjectively better and was less dyspneic, although his temperature remained high and his pulse rapid. Twenty-four hours later, his temperature had risen to 40 C. (104 F.) and his respirations were 39. On December 21, a pericardiocentesis was repeated in the same location,

and 320 cc. of reddish-yellow fluid was withdrawn. Smears showed streptococci, and by the next day cultures proved them to be of the hemolytic variety.

Operation and Course.—On December 22, a pericardiostomy was done. The boy was extremely ill and dyspneic, and had to be moved to the operating room in a sitting posture. With the patient under procaine hydrochloride anesthesia a curved incision was made, beginning in the midsternal line opposite the fourth rib and coursing outward and along the line of the sixth rib for several inches. This rib was exposed and its cartilage excised. The internal mammary vessels were ligated and divided, and the pleura carefully pushed laterally by a finger covered with gauze. The pericardial sac came readily into view and appeared red and edematous. It was grasped with Allis' forceps and incised parallel to and throughout the length of the intercostal opening. Four hundred cubic centimeters of pus, similar to that aspirated the day previous, was evacuated. Cultures failed to show growth of the organism. Fair exposure was obtained, but the incision was found to be 2 cm. above the lowest portion of the pericardium. It was felt, however, that the patient was too ill to justify further rib resection. Many plastic adhesions were already present near the base of the heart, and large flakes of fibrin lay free in the sac. These were removed. Drainage tubes were not inserted. The mouth of the wound was loosely packed with salt gauze and the patient returned to the ward more comfortable, subjectively, than he had been since his admission.

On December 25, two days after operation, flushing of the wound and pericardial sac with a solution of chlorinated soda was instituted every four hours. Drainage, however, was never profuse, and the small opening tended to close rapidly. The whole lower left side of the chest continued to be dull on percussion, the heart remained displaced to the right, and on December 26, roentgen examination showed that the posterior pericardium was still greatly distended. The shadow was 20 cm. in width, and extended to within 2 or 3 cm. of the left lateral wall of the chest (fig. 2). On December 29, the drainage from the wound became much more profuse and more purulent, and it was hoped that the posterior pocket was discharging.

At the same time the wound of entrance in the axilla reopened and began to show a slight discharge. The next day, December 30, the patient was taken to the operating room, still in a sitting posture, and this wound was explored. With the patient under local anesthesia, the course of the bullet was followed downward and posteriorly along the wall of the chest. The eighth rib had been fractured in the posterior axillary line, at which point the sinus entered the chest. A counter incision was made here, and a localized empyemic cavity containing about 100 cc. of pus was evacuated. The bullet lay at the bottom of this cavity and was removed. A partial resection of the eighth rib was thought advisable, but the patient's condition was such that the procedure was not considered justifiable at that time. Dakin tubes were inserted into the empyemic cavity and the sinus of the wall of the chest, and he was returned to the ward as quickly as possible. An x-ray film made the following day did not show any decrease in the size of the pericardial shadow (fig. 3).

On Jan. 2, 1926, the patient was brought back to the operating room and under local anesthesia 7.6 cm. of the fragmented eighth rib were removed. At this time a tense fluctuation could be felt through the compressed lung and thickened visceral pleura, but again it was thought that the patient's condition did not warrant further procedure. He was given a transfusion of 500 cc. of whole blood during the course of the rib resection. Throughout this entire period following admission the boy remained acutely ill, with marked dyspnea and high temperature and pulse rate. It was always a problem whether he could tolerate transportation to the

operating room or any surgical procedure—a condition which enforced the conservatism and multistaged operations employed.

On January 4, thirteen days after the anterior pericardiostomy, the posterior pericardium was approached through the already existing thoracostomy opening. Without anesthesia, an incision was made through 2 or 3 cm. of compressed, dark, already partially fibrosed lung. Eight hundred cubic centimeters of foul pus was evacuated. The patient's respiratory distress was immediately lessened, although his heart did not recede from its displaced position. Two large rubber tubes were inserted to keep the wound open. The patient was returned to the ward in good

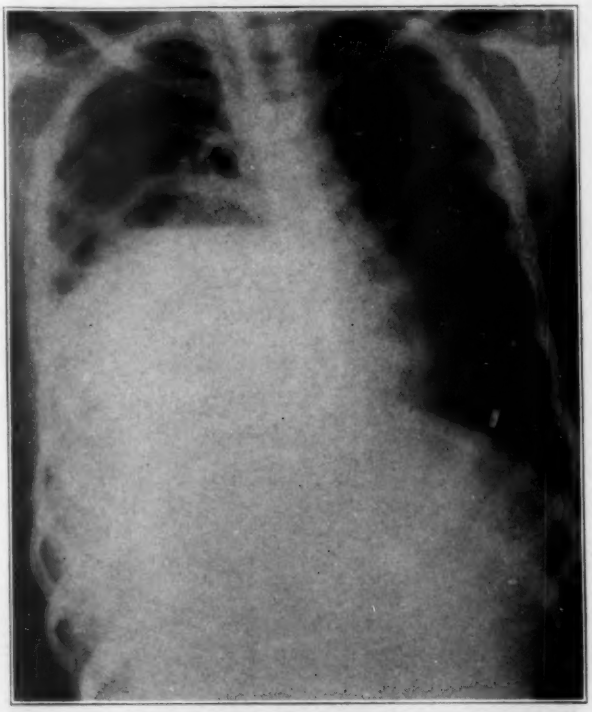

Fig. 2 (case 1).—Roentgenogram of the chest on Dec. 26, 1925. Although 320 cc. of fluid was aspirated on December 21, and 400 cc. removed by pericardiostomy on December 22, the pericardium is still greatly distended.

condition. Cultures taken at the time of this operation failed to show growth of the organism.

After twenty-four hours, irrigations of chlorinated soda were instituted every four hours, as had been done with the empyemic cavity. There was profuse drainage. This was greatly facilitated by the posterior location of the incision, which afforded the optimum postural position with the patient semirecumbent in bed (figs. 4 and 5). According to the report on the roentgenograms taken on January 5, there was marked improvement in the pericardial and pleural cavities, and no fluid in either. A large, empty, thick-walled cavity persisted at the site of the previous left border of dulness (fig. 6).

For the next three weeks, the patient showed slow but steady improvement. On January 27, one of the two large drainage tubes was removed. At this time, the anterior wound was almost healed. On February 3, the second large rubber tube was removed, and several small soft rubber Dakin tubes were inserted. Irrigation was changed from chlorinated soda to saline solution because of the presence of a bronchial fistula, which would probably have been avoided by earlier removal of both large tubes.

Another transfusion of 500 cc. of whole blood was given a few days later, and an effort made to clean out a heavy hookworm infestation. On February 12, the records showed that the patient was steadily improving. He was brighter, stronger and had taken on some weight. The anterior incision had healed. There was little

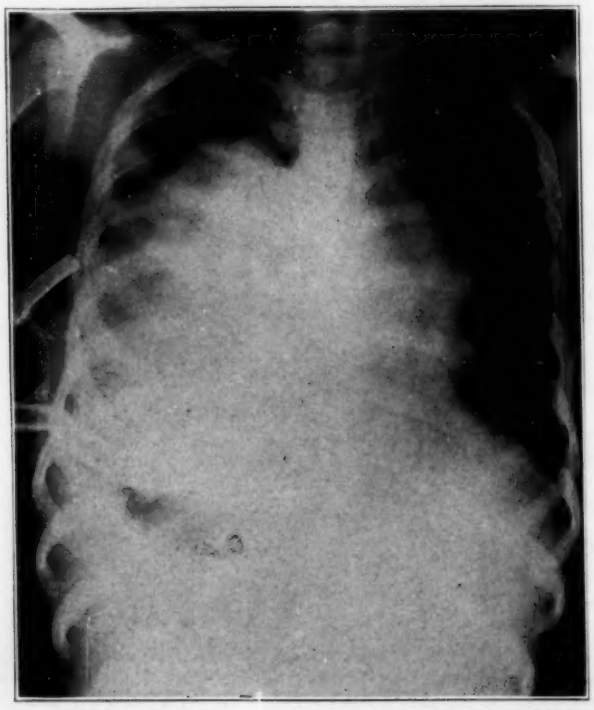

Fig. 3 (case 1).—Roentgenogram of the chest on December 31, twenty-four hours after draining a localized empyema and removal of the foreign body. There is no decrease in the size of the pericardial sac.

discharge from the posterior sinus, which held only one Dakin tube. This last tube was removed on February 16.

On March 11, the report on roentgenograms showed that the appearance of the heart shadow and the left side of the chest was much improved. The diaphragm was now seen and its pleura was considerably thickened, but the pleura at the base was returning to normal consistency. The heart shadow was approximately normal in appearance, except for some persistent displacement to the right. There were increased lung markings on the left side, particularly adjacent to the hilum, but no evidence of a persisting pericarditis or empyemic cavity (fig. 7).

Fig. 4 (case 1).—The wound of the anterior pericardiostomy, performed on Dec. 22, 1925.

Fig. 5 (case 1).—The wound of the posterior transpulmonic pericardiostomy, performed on Jan. 4, 1926.

On May 23, the patient was discharged to the convalescent hostel. He had been on his feet about the hospital for some weeks previous to this time, without dyspnea or unusual acceleration of his pulse. The anterior pericardiostomy wound was completely healed. The posterior wound had contracted to a small sinus scarcely large enough to admit a probe. This connected with the bronchial fistula and, as proved by the discharge of several small pieces of bone, to an osteomyelitic rib.

During the summer months the lad was employed about the hospital grounds. He was kept at light labor out in the sun, and gained markedly in strength and weight. The sinus persisted. X-ray films taken on September 11, showed erosion

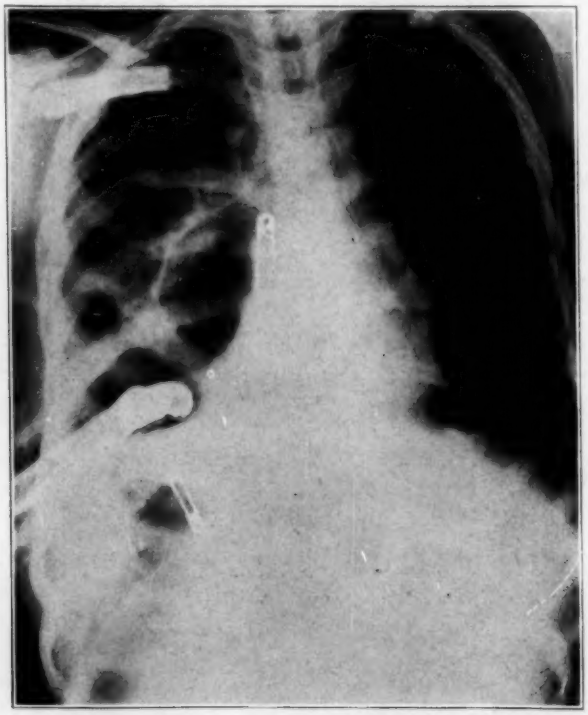

Fig. 6 (case 1).—Roentgenogram of the chest on Jan. 5, 1926, twenty-four hours after the posterior pericardial drainage.

of the eighth, ninth and tenth ribs and a definite but restricted area of clouding at the base of the left lung adjacent to the diaphragm. In general the lungs were clear (fig. 8).

The patient was readmitted to the hospital on September 28, and was operated on the next day. The sinus tract was explored under procaine hydrochloride anesthesia. Two paths were found; one leading to a sequestrum in the eighth rib, and the other to a small abscess still in communication with a bronchus. Resection of 7.5 cm. of the eighth and ninth ribs was done. The roof of the other sinus and of the abscess was removed. A little ether was necessary here, and, while coughing, the patient spat up some pus and thoroughly blew the remaining contents of the abscess through the wound. The edges of the skin were sutured to the pleura, and the wound and widely patent abscess cavity lightly packed with saline gauze.

By October 6, the bronchial fistula had closed, and remained closed permanently. The wound continued clean and granulated rapidly. By October 28, it had again contracted to a small sinus. The boy was discharged once more to the convalescent hostel.

The sinus persisted, and on November 29, the patient was again readmitted to the hospital. Two days later, under procaine hydrochloride anesthesia, this sinus was explored and found to lead to a sequestrum in the body of the tenth rib. Nine centimeters of this rib was excised together with a mass of adjacent scar tissue. Healing was prompt and complete. The patient was permanently dis-

Fig. 7 (case 1).—Roentgenogram of the chest taken on March 11, 1926.

charged from the hospital on Dec. 20, 1926, and from the dispensary on Jan. 18, 1927.

He was brought back for reexamination on March 22, 1927. He was well and strong and able to do ordinary work without unusual fatigue or effect on his pulse. An electrocardiogram did not show any abnormality. The x-ray films showed that except for some generalized increase of the lung markings, a rather central position of the heart and the resected ribs on the left side, there was little to indicate the serious injury suffered by this patient something over a year previously (figs. 9 and 10).

Case 2.[4]—*History.*—Louis Ialungo, an Italian tailor, aged 30, was admitted to the surgical wards of the Cincinnati General Hospital on Oct. 8, 1922, from the

4. Permission to use this data has been kindly granted by Dr. George J. Heuer.

branch or tuberculosis hospital. His illness began about March 1, 1922, with cough, purulent expectoration, weakness, loss of weight and pain in the left side of the chest. His local physician made a diagnosis of tuberculosis and advised rest in the country. He went to a farm and lived in the open air for a month, returning home much improved. In May, an abscess developed on the right side of the back of his neck at the site of a shrapnel wound received in 1916. This was opened, and it healed. In June, an abscess appeared in the right inguinal region near the site of an old appendectomy scar. This continued to drain. In August, two months before admission, the patient began to have pain around his heart and over the left side of the chest. This was accompanied by progressive weakness and shortness of breath, so that he was soon confined to bed. He was admitted to the branch hospital on Sept. 30, 1922, with the diagnosis of pulmonary tuberculosis.

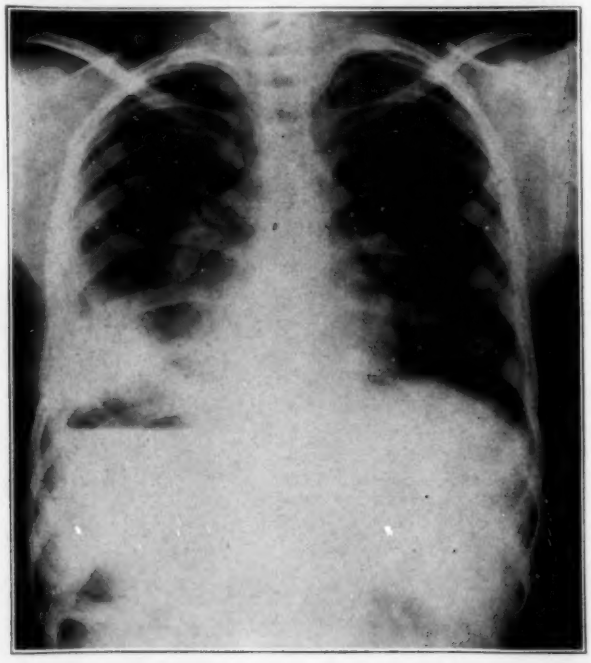

Fig. 8 (case 1).—Roentgenogram of the chest taken on Sept. 11, 1926. It shows a small empyemic abscess which communicated with a bronchus and erosion of the eighth, ninth and tenth ribs.

Examination revealed signs of an enlarged pericardium. This and a complicating pulmonary tuberculosis were confirmed by roentgenologic examination. The sputum was negative for tubercle bacilli, and there were 18,000 white blood cells. A pericardiocentesis was performed on October 6, and 20 cc. of pus was withdrawn from the pericardial sac. Examination of this did not reveal any tubercle bacilli; *Staphylococcus aureus* grew from the culture. The patient was transferred to the general hospital on Oct. 8, 1922, with the diagnosis of purulent pericarditis complicated by pulmonary tuberculosis, moderately advanced.

Examination.—On admission, the patient appeared sallow and anemic, and gave evidence of considerable loss of weight. He was not in pain when quiet, but the slightest effort caused him great distress. There was definite bulging of the entire

precordium from the second to the sixth interspace. The apex beat was easily seen in the fifth interpace, displaced laterally beyond the nipple line. It was diffuse and of wavelike character. The area of dulness was increased in all directions, but was not of the typical "pear shape." It extended 3 cm. beyond the left midclavicular line and 4 cm. beyond the right midclavicular line. The heart sounds were clearly heard over the entire precordium, but were rapid and embryonic. Murmurs or friction rub were not audible. The temperature was 102 F. Roentgen examination of the chest showed the trachea and bronchi to be deflected toward the right. The heart shadow was markedly increased in all diameters, especially on the left. The contour of the shadow was suggestive of pericardial effusion. An area of density

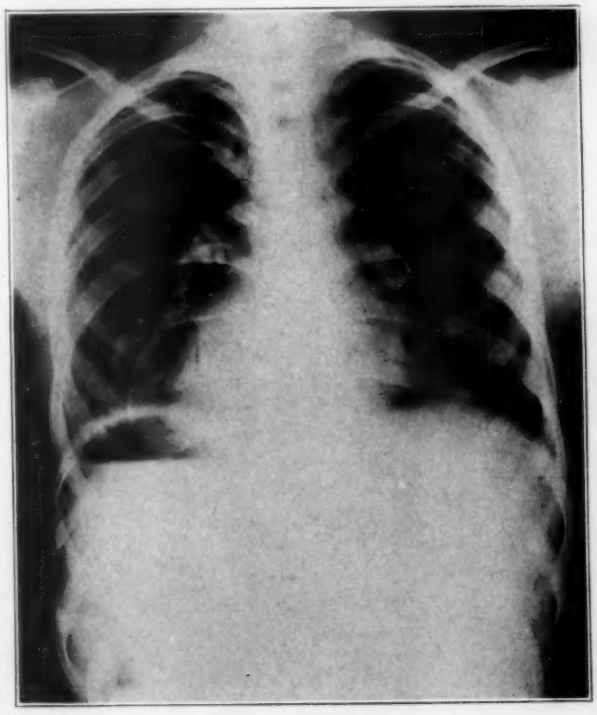

Fig. 9 (case 1).—Roentgenogram of the chest taken on March 22, 1927, three months after complete closure of all wounds.

at the base of the left lung merging with the heart shadow suggested the possibility of fluid there also. Considerable mottling of the fields of both lungs was present.

Operation and Course.—On October 10, the patient was operated on by Dr. George J. Heuer. With the patient under gas and oxygen anesthesia, an incision was made over the fifth costal cartilage; the cartilage resected and the pericardium exposed. It was at once apparent that there was no fluid between the pericardium and the heart, for the heart was in direct contact with the pericardium. Nevertheless, an incision was made through the pericardium, and it was found that the anterior surface of the heart was densely adherent everywhere to the anterior pericardial sac. An attempt was made to separate the pericardium from the heart, and a separation was made with great difficulty over an area perhaps

3 cm. in diameter. The procedure had to be discontinued, however, because the heart muscle was constantly damaged, causing bleeding. The operation in this region was therefore abandoned. The pericardium was closed with silk, as was the superficial wound throughout.

As Dr. Heuer felt sure from the physical and roentgen examinations that there was a large amount of fluid in the pericardial sac, the patient was turned over on his right side, and a rib was resected in the midaxillary and postaxillary line, with the idea of approaching the pericardium from behind. The lung was found adherent to the parietal pleura. An aspirating needle was inserted through the lung into the pericardial sac, and a syringeful of thin pus withdrawn. With a blunt instrument the lung was perforated, and the posterior pericardium opened,

Fig. 10 (case 1).—Patient several months after complete recovery. Note the scars of the anterior and posterior incisions. The patient has returned to work.

with the immediate discharge of a large amount of purulent material. It could be positively determined that the pericardial sac had been entered, since, after evacuation of the fluid, a long instrument could be placed directly against the heart. The pericardial sac was drained with a fairly large rubber tube.

A subsequent x-ray picture showed diminution in size of the pericardial shadow, another proof that the pericardium had been drained.

Postoperative convalescence was satisfactory. The temperature and pulse rate promptly became lower. Drainage was good, and soon became of minimal amount. No irrigating solution was used until the second week, after which the cavity was washed out with salt solution daily. The tubes were removed after three weeks, and on November 10, one month after operation, the patient was up in a chair and in good condition.

Following this there was a flare-up of temperature, and the patient complained of night sweats and pain in his right side. The inguinal sinus was explored, and about 8 ounces of thick, creamy pus was evacuated from a pocket which lay along the lumbar vertebrae. Careful roentgen examination of the entire spinal column, both before and after injection of the inguinal sinus with bismuth paste, failed to show any evidence of a bony pathologic process or of origin of the sinus from the spinal column. A little later, the old cervical sinus reopened and continued to drain.

The patient was discharged on Dec. 21, 1922, ten weeks after operation. His pericardial wounds were healed, and both roentgenologic and clinical evidence showed that his heart had returned to almost normal size. Considerable infiltrate remained at the apex of the right lung and in the upper and middle portions of the left lung.

The subsequent history of this patient's disease is most interesting as it led up to the establishment of the final diagnosis on his last admission. The pericardial drainage wound remained closed throughout the rest of his illness, and there were no further symptoms referable to the heart.

On Jan. 2, 1923, two weeks after his first discharge, he was readmitted, complaining of pain in the lumbar region. The right inguinal sinus continued to drain through a long tract leading toward the tender area. A culture of the discharging pus yielded *Staphylococcus aureus*. Roentgen examination revealed the development of a lower dorsal and lumbar scoliosis with the concavity toward the right, but without destruction of bone. The pulmonary process was little altered. Following some clinical improvement after rest in bed, the patient was again discharged on Jan. 26, 1923.

On March 2, he was again readmitted because he had the same pain in the back. He had definitely lost ground since his discharge. The wound in his neck was closed, but the inguinal sinus was draining profusely. X-ray pictures taken with a rubber tube inserted into the sinus showed that it passed upward and posteriorly toward the spine. There was marked involvement with wedging and loss of substance in the bodies of the first and second lumbar vertebrae. The scoliosis had become more pronounced, and there was pain on pressure over the lower thoracic and lumbar vertebrae. The twelfth thoracic spine seemed definitely kyphotic. The abdomen was full and the flanks tender. A section of tissue taken for biopsy from the sinus tract showed only infected granulations. Several days after admission, there was a profuse pulmonary hemorrhage. A plaster jacket was later applied, and on March 28, the patient was returned to the branch hospital with the diagnosis of tuberculosis of the lungs and spine and a tuberculous psoas abscess, secondarily infected.

On April 8, the patient was admitted for the last time. He was returned because of the development of huge abscesses over both dorsolumbar regions. These were incised by Dr. Mont Reid. As the pus escaped over the skin, small yellow granules were observed, which on microscopic examination proved to be typical actinomycotic mycelia. Tissue curetted for section confirmed this diagnosis. The patient died on April 13, 1923.

COMMENT

The case for surgical drainage of suppurative pericarditis has been unquestionably established by the statistical work of Roberts,[5] Porter,[6]

5. Roberts, J. B.: Am. J. M. Sc. **114**:642, 1897.

6. Porter, C. B.: Ann. Surg. **32**:769, 1900.

Eliot,[7] Rhodes,[8] Klose and Strauss,[9] Williamson,[3] and Winslow and Shipley.[2] In the 133 cases in which operation has been performed, there have been seventy-five recoveries, or 56.4 per cent. In the twenty-nine cases collected by Klose and Strauss in which treatment by aspiration alone was given, there were but four recoveries, or 14 per cent. Cases in which treatment was not given have been universally fatal.

With regard to operative measures, Winslow and Shipley [2] have well pointed out that recovery is not so much a matter of route or technic of drainage, as of the time of operation and the accompanying conditions to which the pericarditis is secondary. Fourteen cases in which drainage was employed following infection from gunshot or stab wounds showed 100 per cent recovery. In those in which there was complicating osteomyelitis, pyemia or respiratory lesions, the recoveries varied from 33.3 to 49.3 per cent. Suppurative pericarditis is never primary, and the prompt recognition and proper treatment of the original lesion has as much to do with the prognosis as the prompt and proper drainage of the pericardium itself.

Concerning routes of drainage, practically every surgeon has attacked the pericardium through the anterior wall of the chest. This is the natural path of approach, since the pericardium lies in the anterior mediastinum adjacent to the sternum and costal cartilages, and this is the one area in which a transpleural operation can be avoided. However, as Curschman [10] first pointed out and as has since been confirmed by many writers, an extensive pericardial exudate lies almost wholly posterior to the heart itself. Postoperative walling-off or pocketing in the posterior pericardium, as in case 1, has been a common experience. The heart sometimes becomes so adherent to the anterior pericardium, as in case 2, that without doing definite damage to the organ itself, it is impossible to separate the two surfaces sufficiently to reach the exudate. Conner [11] has recently recalled the close approach of the pericardium to the posterior wall of the chest in cases of massive effusion, and recommends this route for pericardiocentesis in noninfectious (rheumatic) cases in which aspiration is considered necessary.

In the literature are mentioned several cases of transpleural drainage in which the pericardium was opened through an already existing thoracostomy wound for empyema (as in case 1), or in which the pleura was first opened with the mistaken diagnosis of empyema. Brinton and Collyns [12] reported a case of the latter type, the pericardium

7. Eliot, E.: Ann. Surg. **49**:60, 1909.
8. Rhodes, G. B.: Ann. Surg. **62**:660, 1915.
9. Klose, H., and Strauss, H.: Arch. f. klin. Chir. **119**:467, 1922.
10. Curschman, H.: Deutsche Klin. **4**:401, 1905.
11. Conner, L. A.: Am. Heart J. **1**:421, 1926.
12. Brinton, R. D., and Collyns, R. F.: St. Barth. Hosp. Rep. **19**:271, 1883.

having been incised transpleurally in the fifth interspace in the anterior axillary line. The patient did not survive. Sibley,[13] and Steward and Garrod [14] reported cases in which an empyema was drained and a number of days or weeks later a bulging pericardium incised through this already existing wound, the general pleural cavity thus escaping infection. In Sibley's [13] case, the empyemic cavity lay anteriorly near the heart, and the opening was made just outside the nipple line. This patient did not survive. Steward and Garrod [14] evacuated an empyemic cavity by resecting a portion of the left eighth rib in the scapular line. Three weeks later, they opened a bulging pyopericardium through this same incision. Convalescence was uneventful. West,[15] in commenting on the presentation of this report, mentioned having seen another case of pericarditis in which similar drainage was instituted from behind and in which the patient also recovered. In the discussion which followed the presentation of Peterson's paper, Auchincloss mentioned a case in which posterior drainage was used by Whipple and in which the patient did not survive. I have not been able to find any other record of this case.

Posterior drainage of this sort has certain natural disadvantages which prohibit it from being the method of choice in any except those cases in which, because of an already existing pleuritis or empyema, there is reasonable evidence that the main pleural cavity has been sealed off from the operative field. It has the obvious advantage that in cases in which it can be safely employed it affords perfect postural drainage. Peterson [1] secures this in anterior exposure by placing his patients face downward upon the bed. This is an excellent procedure, but I am certain that many patients will not tolerate this position, particularly in the acute stage of their disease, when it is most important.

Any discussion of suppurative pericarditis always leads to the question of drainage and irrigation. Winslow and Shipley [2] have given complete statistical tables concerning the type of drainage materials used in all recorded cases, and the accompanying results. In both of the reported cases, short rubber tube drains were used in order to keep separated the edges of collapsed lung tissue and pericardium traversed by the incision. I agree with Peterson,[1] however, that wherever wide exposure and good postural drainage can be established, the use of any kind of tube or dam is unnecessary, if not actually harmful. Halsted clearly demonstrated the rôle of drains or any foreign body in abetting infection and the formation of adhesions in the peritoneal cavity. Beck

13. Sibley, W. K.: Brit. M. J. **1**:1192, 1903.

14. Steward, F. T., and Garrod, A. E.: Proc. Roy. Soc., London **1**:15, 1907-1908.

15. West, S.: Lancet **1**:560, 1910. Curschman (footnote 10).

and Moore [16] have shown similar or even greater sensitivity for the pericardial membranes. It seems unwise to insert any foreign body against an already damaged heart, and any attempt to drain the posterior pericardial recess through an anterior incision must of necessity do this. The beating organ can be relied on to keep its surrounding sac empty, provided a potential pocket of dilated posterior pericardium is not encouraged or maintained by a high anterior incision and a supine or semirecumbent position. Such pocketing occurred in case 1, and was the cause of the formation of the walled-off abscess which was later evacuated posteriorly. When the anterior approach is utilized, and it remains the method of choice for a large percentage of cases, I am of the opinion that resection of the fifth, sixth and seventh left cartilages with wide exposure down to the diaphragm and base of the pericardium, as advocated by Poole,[17] affords the best opportunity for complete drainage and consequently the best prognosis for recovery. This should be supplemented wherever possible by postural drainage as suggested by Peterson.[1]

Opinions differ greatly about the value and advisability of irrigations, particularly with solutions of chlorinated soda. The experiences cited by Miller and Andrus,[18] each of whom lost a patient apparently from uncontrollable oozing of blood caused by the constant friction of granulating pericardial surfaces, might prejudice one against this procedure. Hedblom, Poole and Auchincloss,[19] however, have all employed it with success and recommend the procedure. In the Peking Union Medical College, I have seen a surgical solution of chlorinated soda (Dakin's solution) used in three cases of suppurative pericarditis (including case 1), in all of which it gave most satisfactory results. Warm physiologic sodium chloride was used for the first forty-eight hours, after which, at two hour intervals, a surgical solution of chlorinated soda was instilled into the pericardium by a syringe and allowed to gravitate out. These measures seemed to have a most beneficial effect in helping to eliminate the infection.

SUMMARY

1. Two new cases of suppurative pericarditis are recorded: one secondary to a gunshot wound of the chest, the other secondary to what eventually proved to be actinomycosis.

2. Posterior drainage was instituted in both cases with recovery. In one case, a walled-off abscess of the posterior pericardium following an

16. Beck, C. S., and Moore, R. L.: Significance of the Pericardium in Relation to Surgery of Heart, Arch. Surg. **11**:550 (Oct.) 1925.

17. Poole, E. H.: Ann. Surg. **73**:393, 1921.

18. Miller and Andrus, in discussion on Peterson (footnote 1).

19. Hedblom, Poole and Auchincloss, in discussion on Peterson (footnote 1).

anterior pericardiostomy was evacuated through a previously made posterior thoracostomy incision. In the second case, posterior approach was utilized after an unsuccessful attempt at anterior drainage had been made.

3. The advantage of the natural postural drainage of the posterior pericardium afforded by this method of approach is emphasized.

4. The limitations of this approach are suggested, as well as its practicability primarily in certain cases and alternatively in others in which anterior drainage is not feasible.

5. Postural, rather than tube or tissue, drainage is advocated.

6. The use of a solution of chlorinated soda by instillation is felt to be safe and of great value in most cases.

STRANGULATED LEFT DUODENAL HERNIA

REPORT OF A CASE WITH RECOVERY *

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Internal, or retroperitoneal, hernia is an unusual condition characterized by the protrusion of abdominal contents through a congenital, acquired or anomalous opening wholly within the abdomen. The vast majority of these internal hernias are also retroperitoneal, and they occur most frequently in the region of the duodenojejunal junction, about the cecum (pericecal retrocolic) and sigmoid colon. At these points rudimentary fossae are frequently found; when they attain sizable proportions, as they rarely do, they may contain abdominal viscera, and are then properly termed retroperitoneal hernias.

INCIDENCE OF RETROPERITONEAL HERNIA

Some conception of the infrequent occurrence of retroperitoneal hernia may be gathered from the fact that Short,[1] in a survey of the literature in the decade between 1914 and 1924, was able to compile reports of only thirty-eight cases of retroperitoneal hernia of all kinds, including duodenal hernia, retrocolic or pericecal, hernia into the foramen of Winslow, intersigmoid hernia, hernia through the transverse mesocolon, hernia through the broad ligament and several anomalous retroperitoneal hernias. Of the thirty-eight cases, by far the largest number, fifteen in all, were of the left paraduodenal fossa. As the case here presented is of that variety, description will be confined chiefly to the left, or paraduodenal, form.

CLASSIFICATION AND ETIOLOGY OF DUODENAL HERNIA

An excellent monograph on the subject of internal hernia is that of Moynihan (Arris and Gale Lectures, 1897). He described nine fossae about the duodenum in which internal hernias may be found: (1) the superior duodenal fossa (Eppinger); (2) the inferior duodenal fossa (Treitz); (3) the left paraduodenal fossa (Landzert); (4) the right, or mesentericoparietal, fossa (Waldeyer), and (5) the mesocolic fossa. The unimportant, or rare, fossae are: (6) the posterior duodenal fossa (Gruber); (7) the duodenojejunal fossa (Huschke); (8) the recussus intermesocolicus transversus, and (9) the infraduodenal fossa.

The paraduodenal fossa first described in 1871 by Landzert is most frequently seen in the fetus or in the newly born. It is situated on the

* Submitted for publication, Dec. 26, 1928.

1. Short: Brit. J. Surg. **3**:48, 1915; **12**:456, 1925.

left side at a little distance from the ascending duodenum and is formed by the fold of peritoneum (plica venosa) covering the inferior mesenteric vein; it is most apparent when the colon is pulled strongly upward.

A number of theories have been advanced to explain the formation of fossae and folds near the duodenum. Treitz attributed the herniation into these fossae to a combination of tense margins of the fossae, freedom of movement of the intestines and peristalsis. Waldeyer considered the elevation of the peritoneum by blood vessels to be an important factor. Toldt explained the fossae as physiologic adhesions. Other theories give the following causes: embryonic origin, as late descent of the cecum; formation of pockets during intestinal rotation; formation of fusion folds in fetal life and failure of the root of the mesentery to unite with the posterior abdominal wall. Moynihan, Langer and Toldt, Lower and Higgins and others expressed agreement with the view that the fossae into which herniation takes place are formed by fusion folds.

Edmund Andrews [2] considered the term "duodenal hernia" a misnomer and gave an embryonic explanation of its causation. He considered the condition "a congenital anomaly due to imprisonment of the small intestine beneath the mesentery and the developing colon." He expressed the belief that the prevalent conception that these large hernias originate in small peritoneal pouches and grow in size by gradual expansion of the sac is absurd and grotesque. He supported his belief with the following statements:

(1) Differential pressure is utterly lacking within the abdomen so that any *vis a tergo* to account for the formation or growth of such hernias is totally absent.

(2) There are hundreds of similar folds and fossae in the peritoneum, many of which are of much greater size, that are practically never the sites of such hernias.

(3) In all but a very small minority of cases reported, the degree of herniation has been total, or subtotal.

(4) A case of total hernia in a new-born infant has been reported (Left Duodenal Hernia of Vogt).

(5) The herniated viscera are never anything but small bowel. The presence of omentum has never been reported. In only one case (left duodenal hernia of Pybus) were a few inches of the descending colon herniated.

(6) In many of the cases there has been an almost universal growing together of the contents of the sac.

Andrews considered the adhesions to be derived from retroperitoneal tissue rather than due to inflammation.

Space does not permit of a full account of Andrew's theory on the production of duodenal hernia. His theory is plausible but not without objections. My case, for example, was by no means a total or

2. Andrews: Surg. Gynec. Obst. **37**:740 (Dec.) 1923.

subtotal herniation, not more than 4 feet (122 cm.) of small intestine being found in the sac; nor were there any well organized adhesions between adjacent portions of contained intestine.

It does not appear to be necessary to assume differential pressure within the abdomen to account for progressive increase in the size of the hernia. Peristalsis can account for herniation of the small intestine into the lesser sac through the foramen of Winslow or through a rent in the transverse mesocolon as a result of gastro-enterostomy. Why, therefore, cannot the same mechanism obtain as an explanation for the progressive increase in duodenal hernias until they reach a large size? Brown gave other embryonic considerations which led him to discount Andrew's theory. The question, however, is far from settled at present.

AGE AND SEX

The average age, as found in thirty-five cases, was 34.7. The oldest patient was 68 and the youngest was 2. Five cases occurred in children under 15.

Of thirty-six cases in which the sex was stated, twenty-three occurred in males and fourteen in females. It is also interesting to note that in the seven cases collected by the author and in the case here presented the patients were males.

SYMPTOMS AND CLINICAL MANIFESTATIONS OF RETROPERITONEAL HERNIA

There are, no doubt, cases of retroperitoneal hernia in which the degree of herniation is so slight that symptoms are negligible. When the condition progresses to the point where symptoms are of clinical importance, it may assume one of several aspects: (1) recurrent attacks of subacute, or chronic, incomplete strangulation; (2) acute strangulation, and (3) presence of a palpable tumor. Some cases may include the features of all three types.

The case here reported gave a history of recurrent attacks of subacute strangulation, acute strangulation found at operation and the presence of a palpable mass.

It is a singular fact that correct diagnosis is rarely made prior to operation. Most cases are diagnosed simply as intestinal obstruction. As Moynihan pointed out, the characteristics of the abdominal tumor are fairly discernible, as they are noted on percussion and are limited to a definite area of the abdomen. On auscultation over the tumor, gurgling sounds may be audible. Definite peristalsis is likely to be present in cases of acute obstruction. These characteristics of abdominal tumor, however, may be taken for pancreatic, or ovarian, cysts.

Considering in retrospect the features of the case here reported, it would seem that a diagnosis of retroperitoneal hernia might have been

made prior to operation on the basis of (1) the history of recurring attacks strongly suggestive of incomplete intestinal obstruction, and (2) the presence of a large palpable mass to the left of the umbilical region in a patient on whom an abdominal operation had not previously been performed and who did not present the general appearance of one suffering from malignant disease.

TREATMENT

When symptoms of obstruction exist, either in the acute complete form or in cases presenting a history of frequent attacks of incomplete obstruction, the treatment should be surgical. A study of the records shows clearly that the results have been progressively more successful, especially during the last ten years. Short attributed this to the fact that operation is undertaken at an earlier stage. The mortality is undoubtedly influenced by the same factors that govern intestinal obstruction due to other causes but involving the same segment of the alimentary canal. Gangrenous intestine demands resection; despite this, several patients have recovered. The presence of important vessels in the neck of the sac (in the case of left paraduodenal hernia, the inferior mesenteric vein and in the case of right paraduodenal hernia, the superior mesenteric artery) should be constantly borne in mind. Division of the neck of the sac is therefore contraindicated.

In the case here reported, division of the peritoneum close to the vessels lying in the margin of the neck of the sac enabled the surgeon to stretch the constricting portion so as to permit reduction by a combination of taxis and traction. Whenever possible, the sac should be ablated or its mouth closed.

The postoperative care should follow the lines applicable to the management of intestinal obstruction due to other causes. Fluids by hypodermoclysis and intravenous administration of dextrose with due attention to the replacement of the chlorides, which are lacking in the blood (Haden and Orr), are points to be emphasized.

REPORT OF AUTHOR'S CASE

History.—A man, aged 52, was admitted to the Second Surgical Division of Bellevue Hospital, Dr. Harold E. Santee, director, on Oct. 26, 1926. The chief complaints were nausea, vomiting and abdominal pain. Two days prior to admission, the patient was seized with severe cramplike pains in the left midportion of the abdomen. The pain did not radiate; it had persisted since the onset and was accompanied by vomiting of greenish fluid. The vomitus did not contain blood and, up to the time of admission, was not fecal. On the day prior to admission, the patient took an enema, after which there was a tarry stool. Several normal bowel movements occurred thereafter.

The patient had yellow fever twenty years before admission. There was a history of recurring attacks of constipation occurring at intervals of five or six

months for the past twenty years. These attacks closely simulated the present attack and were usually associated with vomiting. The duration of the attacks was from two to three days. After these attacks, the digestion became normal. About six months before admission, during an exceedingly severe attack, the patient was admitted to a hospital in Bridgeport, Conn., where roentgen studies were advised, but he left the hospital before they could be undertaken.

The family history was irrelevant.

Physical Examination.—The patient was well nourished; he had severe pain and apparently was acutely ill. The temperature was 99; the pulse rate, 80 and respiration, 26. There was slight tenderness in the abdomen, which appeared to be more marked in the left midportion. There was slight rigidity of both recti, more pronounced in the left than in the right. Pressure over the middle sector of the left side of the abdomen revealed marked tenderness, and in this region there was a suggestion of a mass which could not be clearly outlined, owing to the degree of tenderness present. The percussion note elicited was tympanitic, with partial obliteration of liver dulness, more marked on the left.

There was no rectal tenderness; masses were not felt.

The results of the remainder of the physical examination were normal in all essential particulars. The white blood cells numbered 11,000, 90 per cent of which were polymorphonuclears.

Examination of the urine showed: albumin, 1 plus; a few granular casts; no pus or red blood cells.

Various diagnoses were suggested prior to operation, among them being perforated gastric ulcer, diverticulitis of the sigmoid with abscess, acute pancreatitis and strangulated internal hernia.

Operative Procedure.—On Oct. 26, 1926, when the abdomen was opened through a left para-umbilical incision, an ovoid mass approximately 7 inches (17.7 cm.) in diameter presented itself immediately beneath the parietal peritoneum but not attached to it. There were a number of large vessels in this peritoneal layer. Inspection and palpation revealed the presence in the mass of loops of intestine together with some fluid. An opening was made in this sac and disclosed about 4 feet (122 cm.) of small intestine, which was markedly hypertrophied, the walls being fully ¼ inch (0.6 cm.) thick. At one point a definite beginning intussusception was present, but the continuity of the lumen was not markedly encroached on. A considerable amount of straw-colored transudate, tinged with blood, escaped from the sac when it was opened. There were strands of yellow fibrinous exudate on the intestine, which was a deep cherry red, showing a definite vascular encroachment of this loop. The lesser peritoneal sac was exposed through an opening in the gastrohepatic omentum and was found empty. Coils of collapsed small intestine were felt free in the lower part of the abdomen, and the cecum and the ascending and descending colon were identified and occupied their normal positions. The transverse colon and the stomach were pushed upward beneath the costal margin by the presence of this mass. The neck of the sac faced to the right, and its edge contained a large vessel which was readily palpable. The sac lay for the most part to the left of the midline. A distended, afferent and collapsed loop of small intestine was seen to enter and leave the cavity.

A left rectus muscle-splitting incision was made in the midpoint opposite the umbilicus. The mass was exposed and the sac opened. The contents were released and freed without division of the vascular neck of the sac by stretching and dividing fibrous bands close to this vascular area. The intestine was pushed from the left side and pulled from the right beneath this vascular band until it had been completely reduced. The sac was then inverted by passing it beneath this band and

the greater portion of it excised, its edges being closed together with a running locked suture of no. 1 plain catgut. The intestine, which was involved in the sac, was again inspected; as it appeared viable, it was replaced in the abdomen. Closure by layers was effected with no. 1 chromic catgut for the peritoneum and silkworm gut retention sutures for the rectus sheath. Drainage was not instituted.

Postoperative Course.—Following the operation, fluids by mouth were withheld for thirty-six hours, during which time the patient received two hypodermoclyses of 1,500 cc. each on the first postoperative day and three of 1,000 cc. each on the second. Vomiting occurred on the second day as a troublesome symptom.

Author's case of strangulated left duodenal hernia; note proximal coils of distended small intestine, and collapsed distal coils.

Gastric lavage proved effectual in promptly clearing it up. By the third postoperative day the patient was beginning to take fluids without vomiting, and colonic irrigations were giving satisfactory results. On the fourth day an enema was productive of a large, dark brown, fluid stool accompanied by much flatus. The highest temperature was reached on the night of the fourth postoperative day; at this time, the patient had a productive cough, and the question of pulmonary involvement was raised.

Thereafter, recovery continued without any untoward incident, except that there was a heavy feeling in the abdomen. The wound healed by primary union, and the patient was discharged on Nov. 27, 1926, his thirty-second postoperative day.

Follow-Up Notes.—The patient returned to the follow-up clinic for examination, March 20, 1927, approximately five months after his operation. At that time he was back at work, was still having considerable trouble with gas, and a small postoperative ventral hernia was present. He was given an abdominal belt and requested to return for subsequent observations, but he never returned to the clinic. All further efforts to trace him failed.

The first series of collected cases is that of Moynihan,[3] who found reports of eight patients successfully operated on and ten in which death occurred with or without operation. In 1914, Short [4] presented fifteen additional case reports, in eleven of which the patients recovered after operation and in four of which they died. In a second study, published in 1925, he [5] gathered fifteen more cases that had been reported in the decade from 1914 to 1924; eleven of the patients recovered and four died. Short did not include cases discovered post mortem in which the condition was unsuspected during life, but confined himself to those in which symptoms were present and, in most cases, operation performed.

In a review of the literature from January, 1925, to July, 1928, reports have been obtained of seven cases of left paraduodenal hernia in which operation had been performed. I report the eighth. In addition, Liebers [6] recorded observations made at autopsy in a case complicated by miliary tuberculosis in a girl of 3, and Forlini [7] contributed reports of five cases, all of which were discovered at autopsy. Most of these patients died from other causes, and operation was not indicated or performed in any of them. During this period there have been reports of four cases of right duodenal hernia in which operation was performed.

Since the six cases of left paraduodenal hernia previously mentioned were discovered only at autopsy, I shall not consider them further.

A summary of the eight authentic cases is given in the accompanying table.

DETAILED DESCRIPTION OF CASES REPORTED SINCE 1924

CASE 1.[7]—A man, aged 22, was well until Jan. 27, 1927. He then developed severe and colicky pain in the left upper quadrant of the abdomen. He was admitted to the hospital on Jan. 28, 1927, with a temperature of 97, pulse rate 80 and respiration 20. He was quite prostrated, perspired freely and suffered at intervals of from ten to fifteen minutes with acute abdominal pain, mostly referred to the left upper quadrant.

Examination showed slight distention above the umbilicus. During a spasm of pain, the abdomen was rigid. Some dulness was present on the left flank.

3. Moynihan and Dobson: Retroperitoneal Hernia, ed. 2.
4. Short (footnote 1, first reference).
5. Short (footnote 1, second reference).
6. Liebers: Ztschr. f. Kinderh. **42**:676, 1926.
7. Forlini: Arch. ital. di chir. **16**:482, 1926.

There was no tenderness over McBurney's point, but marked tenderness was present over the left upper quadrant just to the left of the midline about 1 or 2 inches (2.5 or 5 cm.) above the umbilicus. The leukocyte count was 17,500; the urine was normal. The case was considered one of intestinal obstruction.

Operation was performed on Jan. 29, 1927, under intratracheal ether. A left rectus incision was made, extending to just below the umbilicus. When the abdomen was opened, bloody fluid was found. The left upper quadrant was then explored and several loops of contracted small bowel were drawn up, commencing about 18 inches (45.7 cm.) below the duodenojejunal flexure. Above the contracted bowel, a mass of small bowel was found herniated into the cavity bounded above by the transverse mesocolon, and the hernia was held in its position by a band of omentum extending from the left transverse mesocolon obliquely down

Summary of Cases of Left Paraduodenal Hernia in Which Operation Was Performed Reported Between 1925 and 1928

Author	Age	Sex	Intestinal Obstruction	Operation	End-Result
Malcolm: J. Canad. M. A. **17**: 449 (April) 1927	22	M	Acute	Reduction	Recovery
Kuschewa and Malinowsky: Zentralbl. f. Chir. **54**: 525, 1927	33	M	Acute	(1) Reduction, resection, intestinal anastomosis: (2) excision of part of sac and separation of adhesions	Recovery
Serra: Ann. ital. di chir. **6**: 412, 1927	9	M	Chronic	Reduction; suture of edges of sac	Recovery
Erdély: Deutsche Ztschr. f. Chir. **205**: 120, 1927	31	..	Chronic	Reduction	Recovery
Hernandez: Rev. de med. y chiruj de la Habana **31**: 920, 1926	48	M	Chronic	Reduction	Recovery
Christophe: Bull. et mém. Soc. nat. de chir. **52**: 1000, 1926	37	M	Chronic	(1) Exploratory laparotomy; (2) jejunostomy and biopsy	Died
Eitel: J.-Lancet **46**: 131, 1926.....	22	M	Acute	(1) Reduction; (2) jejunostomy; (3) closure of fistula by resection and end-to-end anastomosis	Recovery
Coley	52	M	Acute	Reduction and excision of sac and suture of edges of sac	Recovery

and anchored into the tip of the appendix. The omentum, which had caused the hernia, was removed. When the herniated mass was removed, the color and contour of the bowel became normal. There was no necessity of resection. The abdomen was closed without drainage. Recovery was uneventful.

After careful consideration of this case report, it would seem that it was unquestionably an example of a left paraduodenal hernia.

CASE 2.[8]—A man, aged 33, six hours before admission had severe abdominal cramps and vomiting, but no gas or bowel movement. The abdomen was distended and painful; the tongue was dry; the pulse was fast and weak. The patient had had abdominal pains for two months prior to admission; flatulence and constipation had occurred frequently but had disappeared when cathartics were used.

8. Kuschewa and Malinowski: Zentralbl. f. Chir. **54**:525, 1927.

Immediate operation was performed under general anesthesia. Incision was made in the midline. In the left half of the abdomen, a round elastic tumor covered with a shining serous membrane was found. To the left of the tumor the empty descending colon was stretched down on the right, the cecum drawing toward the midline. In the upper part of the body cavity were seen a few loops of inflated small intestine. On drawing the cecum to the right, one found a narrow hernial opening in which two pieces of intestine were confined. The projecting end of the ileum was caught at its entrance into the cecum so that a portion of the wall of the latter was also included in the ring. The strangulating ring was separated with the index finger as was the anterior wall of the sac almost up to the descending colon. In the sac, which proved to be a retroperitoneal pouch, there was a completely gangrenous section of small intestine. Resection was effected by end-to-end anastomosis. The abdomen was closed. Part of the ileum, 327 cm., was resected. No postoperative complications occurred. The patient left the hospital in one and one-half months.

After working two and one-half months, he was readmitted with subacute intestinal obstruction. On palpation, pain was felt in the left part of the abdomen under the ribs toward the umbilicus. Incision was made in the old scar, and many adhesions were found. When the intestines were pushed to the right and the flexura lienalis to the left, a large cavity was revealed; it was limited on the left and above by the large intestine and led into the abdominal cavity proper. The small intestine issued from the depths of the hole under the transverse colon. This large cavity, covered with serous membrane, was a remnant of the retroperitoneal pouch, the anterior wall of which was divided at the first operation and which had remained as firm scar tissue adhesions between the parts of the flexura lienalis. This coalescence brought the two parts of the large intestine nearer together and formed a pointed corner between them. After all the adhesions were separated, the wound was closed; it healed by first intention. The patient remained under observation for one month. It was necessary to use cathartics. He complained steadily of abdominal distention and painful peristalsis. When he left the hospital he had gained in weight.

CASE 3.[9]—A boy, aged 9 years, had had an attack which began thirty days before admission to the hospital, with a rise in temperature, abdominal pain, vomiting and hiccup. The vomitus was not fecaloid. For ten days, the patient had suffered from colicky abdominal pain and fever, nausea and vomiting of almost all food taken. The boy was thin and anemic; the pulse was weak and rapid. The abdomen was symmetrical; the left half in the region above the umbilicus was pushed out, and the rest was notably flat. In the distended region, there were thick loops marked by painful peristaltic movements.

In the left half of the abdomen, palpation revealed a resistant mass, the size of a large orange, of soft, elastic consistency, like a vesicle full of air. The outlines of the mass were not clear.

Median laparotomy under ether revealed an internal hernia near the duodenojejunal angle. Moderate inflammation of the peritoneum and proximal loops distended with fluid and gas were found, the latter completely empty and contracted. The first loop was covered for the most part by a peritoneal fold which constituted the anterior wall of a pocket the entrance of which was near the duodenojejunal angle. It was comparatively easy to retract the entire loop from the sac. There were no evidences of stricture on the loop, only a slight modification of the coloring and the consistency of the intestinal wall.

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9. Serra: Ann. ital. di chir. **6**:412, 1927.

The loop was replaced in the abdominal cavity, and the edges of the neck of the sac were sutured with the wall. The postoperative course was regular. Emission of gas and feces occurred after twenty-four hours. Food was taken in abundance and was well tolerated on the second day. The condition was cured, and the patient quickly improved in general health.

CASE 4.[10]—A farmer, aged 31, complained for eight months of repeated abdominal cramps associated with a rise in temperature, tympanites, vomiting, obstipation and loss of weight. For three weeks prior to operation, a fluctuating tumor, the size of a man's fist, was palpable in the left side of the abdomen. At physical examination the abdomen below the left costal arch and at the level of the umbilicus showed an uneven and soft, slightly resistant mass, not adherent to the abdominal wall. The intestinal outlines were not palpable. Haber's syndrome was absent. Abdominal pain or distention was not present.

At operation the omentum was found adherent to the anterior abdominal wall, the tumor and the adherent loops of small intestine. The slightly oval tumor, the size of a man's fist, was found adhering above to the mesocolon and below to the spinal column, and was enveloped in a soft, elastic, grayish-white, fibrous membrane. There was no fluctuation. The tumor was isolated and found to be a duodenojejunal hernia, consisting of 50 cm. of small intestines of which the first jejunal loop had entered the hernial sac at the flexura duodenojejunalis. After the sac was opened, the distended small intestine was emptied and withdrawn into the abdominal cavity. The sac was reduced, and the abdominal wall sutured. The wound healed by primary intention. The patient made an excellent operative recovery. Two and a half years later, he had gained 14 Kg. in weight, had regular bowel movements and no pain.

CASE 5.[11]—A man, aged 48, entered the clinic, June 30, 1924. He had suffered from pains at the level of the umbilical region for many years in the form of intermittent crises, accompanied by vomiting, tympanism, cold sweats and constipation. The pains "bent him double" for two or three days, and thereafter digestion was difficult. Evacuation had never been easy. The patient entered the hospital after an especially acute attack.

He was thin and undernourished. Hyperesthesia of the umbilical region was present, with a vague sensation of a swelling, painful on pressure. The upper part of the abdomen was slightly distended and tympanitic. Concentrated enemas caused the expulsion of only a small amount of fecal matter.

Roentgenographic examination showed obstruction in the small intestine, below the greater curve of the stomach and at the level of the duodenum. The diagnosis was internal hernia, probably in one of the duodenal fossae.

Median incision was made under ether, operation being performed as quickly as possible. The duodenum was reached by raising the transverse colon. A part of the small intestine was a little distended and penetrated into the peritoneal sac at the left with its opening toward the right. Guided by touch, the operator slowly drew out the jejunum. The cavity admitted three fingers. At one point in the herniated area a stricture was formed by the viscera, but without greatly diminishing its caliber. The sac was not obliterated because the surgeon feared doing too much, and the probability of the intestine again occupying this fossa did not equal the risk of prolonging the anesthesia. Twelve hours after the operation, a dose of solution of pituitary was injected.

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10. Erdely: Deutsche Ztschr. f. Chir. **205**:120, 1927.

11. Hernandez: Rev. de med. y ciruj. de la Habana **31**:92, 1926.

Convalescence was somewhat difficult, but after the eighth day the patient recovered rapidly. The abdominal wall suppurated. In twenty-nine days, the patient was cured. The author expressed the belief that this is the second or third case in the literature in which a diagnosis was made before operation and the patient recovered completely after operation. The length of time the patient was observed after operation was not stated.

Case 6.[12]—A man, aged 37, entered the surgical clinic of the Hôtel-Dieu in Paris, in February, 1922, for a tumor which had developed at the left of the median line of the abdomen. In 1917 he suffered with indigestion as a result of poor nutrition and on absorption of fatty foods. In July, 1920, he had intestinal trouble and alternating attacks of diarrhea and constipation, the diarrhea being preceded by a slight sickness (colic and sometimes vomiting). All these symptoms ceased, however, when diarrhea succeeded constipation. Six weeks before he came to the clinic he was awakened one night by dull and continued pains. The presence of a tumor, which had existed since that time, was ascertained.

At admission on February 13, a tumor the size of a mandarin, a little dented, stationary and sensitive to pressure, was found between the umbilicus and the left costal edge. A barium sulphate enema revealed that the colon was filled regularly without the least stoppage at any point. The splenic angle was situated high under the diaphragm. It was ascertained definitely by palpation that the tumor was slightly posterior to and independent of the colon.

Operation was performed on March 13, 1922, by Hartmann. A left rectus incision was made, and it was possible to lift up the colon and see a red, lobed tumor, which was stuck to the mesenteric edge of the first jejunal loop and adherent to the fourth portion of the duodenum. As the growth was considered a ganglionic retroperitoneal tumor, the abdomen was closed, and the patient was cured temporarily. A month later pains reappeared more frequently, were more distressing and were accompanied by a hardening of the tumor.

In August, 1922, digestion became slow and difficult, and the patient grew thin. Pains were felt throughout the left side of the hypochondrium, and were especially severe after meals.

A roentgenologic examination was made by means of a barium sulphate meal, so that the intestinal tract could be studied.

The general condition was precarious. The thorax was very long; the ribs were prominent. The panniculus adiposus was totally absent. The patient weighed only 40 Kg. Duodenal stagnation was clear and the author proposed duodenojejunostomy. The patient refused, however, and treatment followed. The urine did not contain sugar or albumin; the Bordet-Wassermann test was negative. In October, the patient weighed only 36 Kg., and the pain grew more intense. Finally, operation was performed.

A median incision was made; the liver was found to be normal, the stomach relatively small and the pylorus thin and open. Numerous adhesions between the gallbladder and the duodenum, due to the previous operation, were liberated. The abdomen was full of large ganglions, and the tumor, which was retroperitoneal, was large and resistant.

Jejunostomy was performed according to the technic described by Gregoire.[13] The angle formed by the mesenteric and colonic vessels was sufficiently opened so that an anastomosis could be made with a straight intestinal needle in two planes with fine silk.

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12. Christophe: Bull. et mém. Soc. nat. de chir. **52**:1000, 1926.
13. Gregoire: J. de chir. **19**:499 (May) 1922.

A puncture was then made into the tumor about a fingerlength below Treitz' ligament, but gave no result. At this place, the posterior parietal peritoneum, then a rather thin wall which gave access to a pouch containing from 50 to 60 cc. of bloody fluid, was incised. A sponge brought out some whitish detritus like milk curds. A fragment of the wall was taken for examination. A drain was placed in the sac and another in the left side, and the abdomen was closed.

The drain in the side was removed on the tenth day; during the first few days, from 200 to 250 Gm. of whitish liquid, i.e., ingested milk, was removed through the other drain.

Microscopic examination of the ganglions showed only lesions of chronic inflammation, and to the author's great astonishment the wall of the cyst had the structure of normal intestine.

The quantity of liquid drained diminished progressively; digestion became good and the appetite excellent. It was hoped that the intestinal fistula would heal, but on November 21 fever set in; laryngitis developed, and the patient died on November 23.

CASE 7.[14]—A man, aged 22, complained of vomiting, abdominal pain, nausea, belching of gas and failure to pass flatus or fecal matter for six days. For seven years he had suffered from similar attacks occurring about once a year and lasting for from two days to a week. Considerable tenderness was present in the right lower quadrant, but pain, increasing in severity, seemed to be most severe in the left lower quadrant. The patient had not passed bloody stools. The history was otherwise essentially unimportant.

On physical examination, the patient was in great pain, with rapid pulse of poor quality and with subnormal temperature. The abdomen was distended. Generalized tenderness and rigidity were present. There was dulness in both flanks. Tenderness over McBurney's point was more marked than elsewhere. The preoperative diagnosis was acute appendicitis.

The abdomen was opened through McBurney's incision, and considerable free fluid was found in the peritoneal cavity. While an attempt was being made to remove the appendix, a pronounced retroperitoneal tumefaction was discovered, and in order to determine its character, a gridiron incision was enlarged by cutting half way through the rectus sheath and muscle to enable the introduction of the entire hand into the peritoneal cavity. A considerable portion of small bowel was found to have herniated retroperitoneally through an opening to the left of the vertebral column, particularly in the region of the paraduodenal fossa, the hernial opening being about the size of a fist. The exact relation of the hernial ring could not be made out on account of the poor condition of the patient. The bowel was pulled out of the hernial sac and brought into the main peritoneal cavity. The part of the bowel that had herniated was distended and blue.

The patient passed bloody stools the first day after operation and vomited repeatedly. Gastric lavage was given frequently. Saline hypodermoclyses were administered. On the third day, the vomiting was fecal, and abdominal distention increased. The temperature was 101 F. and the pulse rate 120.

With the patient under 1 per cent procaine hydrochloride, the peritoneal cavity was opened through an incision in the left flank. A moderate amount of clear fluid was found free in the peritoneal cavity. Volvulus and a proximal loop of the jejunum were present. The hernial opening was examined and found empty. Jejunostomy (evidently high up) was performed by the introduction of a large silver catheter securely placed by pursestring suturing of the presenting

14. Eitel, G. G.: Journal-Lancet **46**:131, 1926.

intestine stitched to the parietal peritoneum. During the operation, the patient was given 1,000 cc. of physiologic sodium chloride solution. There was considerable improvement on the following day; the temperature was 101 F. and the pulse rate, 120. One thousand cubic centimeters of 3 per cent saline solution was given. The general condition grew better, and the catheter was removed on the fourth day. During the three following days, rapidly progressive emaciation and evidence of marked dehydration were noted; no doubt these changes were due to excessive loss of fluid because the fistula was so high up in the intestine. Following a transfusion of blood on the thirteenth day after the first operation, the fistula was closed by resection of about 6 inches (15 cm.) of small intestine; a full excision of the mesentery and an end-to-end anastomosis were made, catgut and fine silk being used for sutures. For two days following, the patient had a stormy course, with rapid pulse, fecal vomiting and marked abdominal distention. He was given repeated gastric lavage, hypodermoclyses with 3 per cent saline solution, a digitalis preparation and small doses of morphine. On the third day he began to improve. At present, he is well and back at his regular work.

COMMENT

In the cases characterized by chronic intestinal obstruction, a laparotomy with reduction of the hernia should be successful in the majority of uncomplicated cases. In cases characterized by symptoms of acute intestinal obstruction, however, the prognosis is dependent on several factors, the most important of which is undoubtedly the rapidity with which operation follows the onset of symptoms. Delay until toxemia and paresis have occurred makes the outlook much more hazardous. Several patients in the series reported in the literature withstood multiple operations, including intestinal resection.

One of the most noteworthy of these is the patient of Eitel, who survived three operations, the last of which was the resection of 6 inches of jejunum. From a study of his case report, it would appear that hypertonic saline solution and blood transfusion were factors in the fortunate outcome.

Kuschewa and Malinowsky's patient also survived resection and intestinal anastomosis.

The combined statistics show that there were thirty-four recoveries and seventeen deaths.

CONCLUSIONS

1. Retroperitoneal hernia is a relatively rare condition, since only thirty-eight reported cases of all types were found by Short in a ten-year period.

2. Hernia into the left paraduodenal fossa is by far the most common variety of retroperitoneal hernia. Forty-three cases of left paraduodenal hernia which produced symptoms during life were reported by Short in 1925. I have added seven more cases and report an eighth, bringing the total number to fifty-one.

3. The symptoms are for the most part those of intestinal obstruction, but the presence of a mass to the left of the median line is important. Diagnosis is seldom made before operation.

4. Treatment consists in reduction of the herniated intestine with care to avoid injuring the vessel which lies in the free edge of the neck of the sac. Partial excision of the sac or obliteration of its cavity is advisable whenever possible. The condition of the bowel may necessitate resection.

5. The mortality rate after operation has been decreasing, there being one death in a recent series of eight cases. This may be attributed in part to more prompt surgical intervention in cases presenting symptoms of intestinal obstruction. The mortality rate will probably approximate that which obtains for cases of intestinal obstruction in general. The intravenous use of dextrose and hypodermoclyses of saline solution are of value in the postoperative care.

INTUSSUSCEPTION DUE TO INTESTINAL LIPOMA IN AN ADULT, FOLLOWED BY GANGRENE IN THE ABDOMINAL WALL

PLASTIC OPERATION FOR REPAIR OF ABDOMINAL WALL *

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J. W. M., a farmer, white, aged 67, was admitted to the hospital on Dec. 14, 1927, complaining of great pain in the abdomen, constipation and vomiting. Two days before admission, after eating a big dinner, he was suddenly seized with cramplike pains in the lower part of the abdomen. The pain was severe, and the lower part of the abdomen became somewhat distended. He took enemas and purgatives. There were fair results from the enemas, but the purgatives accentuated the pain and did not produce results. He then began to vomit and soon vomited large quantities of brown, fecal smelling material. A diagnosis of intestinal obstruction was made. The patient had had a somewhat similar but much milder attack about ten years before admission, but soon recovered. He had been fairly healthy most of his life, but for many years had had chronic constipation which had been much worse recently. He had malaria and typhoid fever when a young man.

On admission, the patient's temperature was 99 F., the pulse rate 96 and respirations 18. He was vomiting, and gastric lavage brought away 16 ounces (473.1 cc.) of foul brown fluid resembling liquid fecal matter. Marked abdominal distention and pain were present. The patient was quite fat. Under a combination of local, ethylene and ether anesthesia, a McBurney incision was made. When the peritoneum was opened, a considerable quantity of straw-colored fluid was evacuated. The intestines were greatly dilated. An indefinite soft mass was felt in the upper right side of the abdomen. The cecum could not be demonstrated. This mass could not be brought into the wound, so the incision was enlarged. The greatly distended bowels were delivered into the wound. It was impossible satisfactorily to manipulate them because of the distention, so an intestinal loop was opened; first a purse-string suture was placed and then the bowel was incised within the grasp of the purse-string suture, and a large, soft rubber tube was inserted. Through this tube much fecal matter and gas were evacuated, and the distention was reduced. A small amount of fecal matter was spilled while this opening was being made, but it was mopped up and the wound was flushed with an antiseptic solution. After the tube was removed, the purse-string suture was tied and reinforced by two similar sutures of linen. The incision was again extended, this time by incising the right rectus muscle upward from the inner end of the enlarged McBurney's incision. Then the upper mass could be delivered into the wound. It proved to be the cecum, into which about 3 feet (91 cm.) of the lower ileum had become invaginated. The intussusception was reduced. The bowel was not gangrenous, but a considerable

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* From the Surgical Department of St. Elizabeth's Hospital.

* Read at a meeting of the Southern Surgical Association, at White Sulphur Springs, W. Va., Dec. 13, 1928.

Fig. 1.—Lipoma of the ileum, measuring 2.5 by 2.5 cm. Most of the surface is covered with intestinal mucosa.

Fig. 2.—Section of lipoma from the ileum, showing distinct capsule enclosing the fatty tissue.

Fig. 3.—Diagrammatic drawing of lipoma of intestine. It should be noted that most of the lipoma projects into the lumen of the bowel.

quantity of serous fluid had accumulated in the peritoneal pocket formed by the outer coats of the bowel involved in the intussusception. After the ileum was reduced entirely, the ileocecal fold of fat was sutured to the mesentery with plain and tanned catgut in order to make the tissues stiffer and prevent a recurrence of the intussusception.

About 18 inches (45.7 cm.) above the terminal ileum was a tumor which appeared to obstruct the lumen of the bowel. It was soft and seemed to be a fatty growth. While it projected slightly from the concave side of the bowel, most of it was in the lumen. It apparently was the head of the intussusception and doubtless caused the intussusception by partially obstructing the fecal current and by being forced down by peristaltic waves. After the bowel was clamped with soft-bladed clamps, the growth was removed through a transverse incision. The wound was closed by suturing the wall of the bowel with a continuous suture of no. 00 tanned catgut and then burying this with two rows of linen placed as continuous

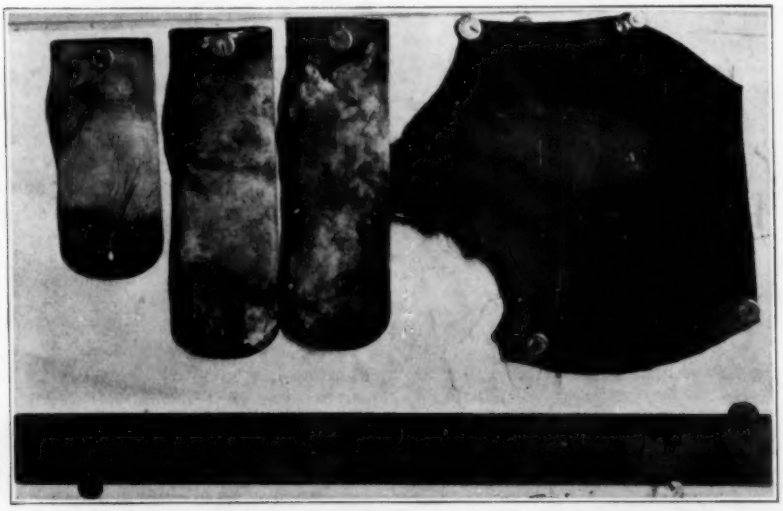

Fig. 5.—Rubber patch from an inner tube and three pieces of metal that were used for temporary repair of the abdominal wall. The rule is in inches.

right-angle sutures. An oblique enterostomy was made just on the oral side of this wound, and in it was placed a soft rubber catheter. An interrupted suture of 00 tanned catgut was placed in the bowel where the catheter emerged and was passed through the parietal peritoneum so as to fix the site of the enterostomy to the abdominal wall. The straight incision upward through the right rectus was closed with interrupted sutures of coarse silkwormgut. The rest of the wound was closed in layers with no. 1 tanned catgut. The enterostomy tube was brought out through the outer end of the McBurney incision. The skin was closed with a continuous suture of 00 tanned catgut.

The general anesthetic was given for one hour and fifty minutes, and the operation lasted two hours and ten minutes. The pulse rate was 96 at the beginning of the operation and 120 at the end.

The specimen consisted of the lipoma, which measured 2.5 by 2.5 cm. On the peritoneal surface there was a small projection of the lipoma, but most of its

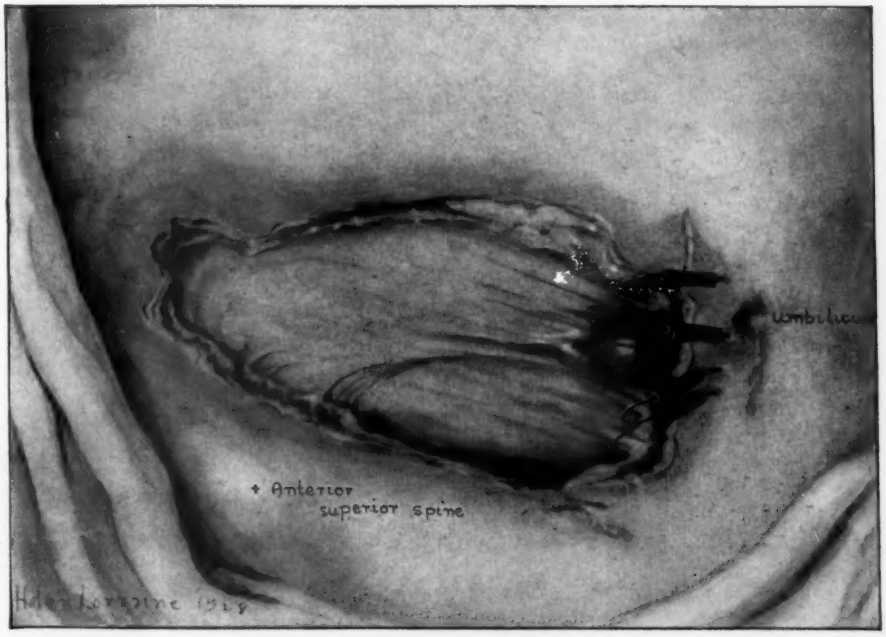

Fig. 4.—Gangrene of the abdominal wall, eight days after the first operation. A loop of bowel is protruding through the gangrenous tissue at the inner portion of the incision.

surface was covered with the mucosa of the intestine (figs. 1 and 2). It grew from the portion of the intestine opposite the mesentery and pushed in the mucous membrane so that most of the tumor was within the lumen of the bowel. It appeared to spring from the submucosa (fig. 3).

The immediate recovery of the patient after the operation was satisfactory. Two days later, a gangrenous area was noted at the tip of the flap that was made by extending the incision along the right rectus muscle from the inner end of the McBurney incision. This affected area was removed with the endotherm knife, and a considerable amount of necrotic material beneath the skin was revealed. The wound was packed with gauze soaked in 2 per cent solution of formaldehyde. It was hoped that this treatment and drainage would be satisfactory to check the gangrene, but it continued along the region of the flap outlined by the two incisions.

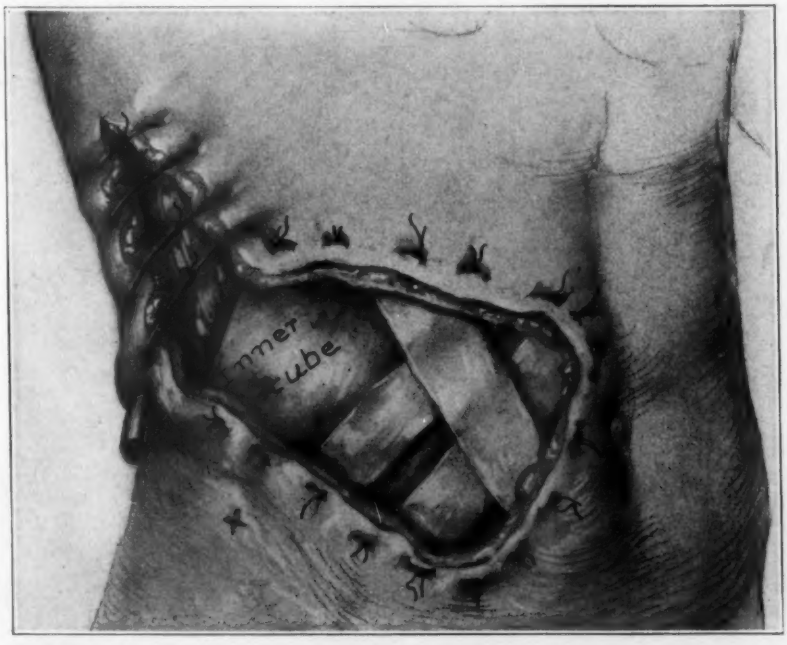

Fig. 6.—Temporary repair of the abdominal wall after the gangrenous tissue was excised. The patch from the inner tube and the supporting metal strips were all that retained the intestines within the peritoneal cavity.

The bowels moved well, and the enterostomy tube was removed six days after its insertion. The abdominal contents were prevented from being extruded merely by some of the through-and-through sutures that extended from the gangrenous tissue on one side to apparently healthy tissue on the other. It was obvious that any straining or coughing would soon loosen this slender restraint, and the patient would be disemboweled (fig. 4). The gangrenous area, however, had become so extensive that it was impossible to close the abdominal wall after the gangrenous material was removed even if it had been advisable to do a plastic operation in the presence of infection. The problem was not a simple one. It consisted, first, in checking the gangrenous process and, second, in retaining the intestines within the abdominal wall until the infection could be overcome and some plastic operation

for closure could be done. As the transplantation of a flap at the time was impossible, on account of the size and the locality of the defect and of the presence of infection, and as removal of all the gangrenous area would make the defect still larger, it was obviously necessary to utilize some artificial means of retaining the intestines in the abdominal cavity until the infection could be overcome.

Hertzler[1] showed that certain types of foreign bodies, such as cork, can be placed in the peritoneal cavity under aseptic conditions and will be rather rapidly covered with an endothelial membrane practically identical with the peritoneum. Rubber in certain forms appears to be almost nonirritating to the tissues. Dentists make use of this nonirritability of rubber in forming plates for teeth and in other types of dental work.

As the patient was quite ill, it seemed unwise to attempt to make or obtain any apparatus that might take much time to secure. Consequently, a section of a thick

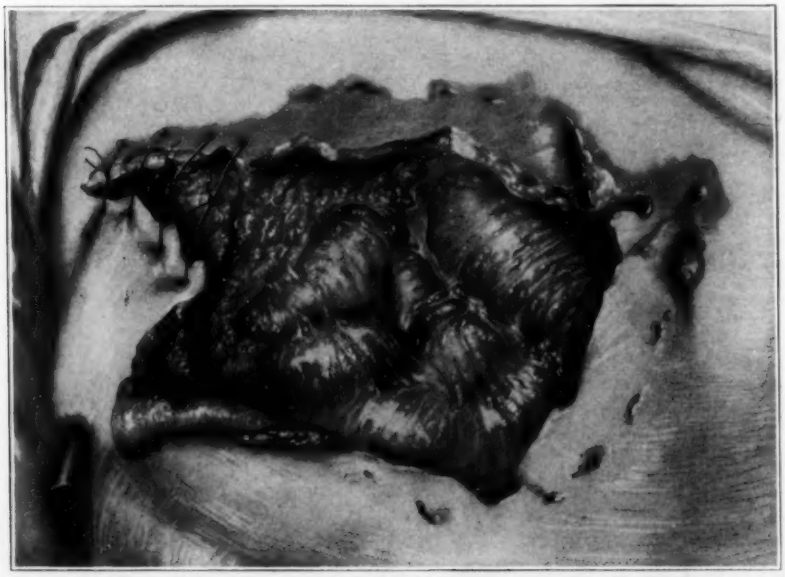

Fig. 7.—The wound immediately after the removal of the rubber plate and metal supports. The firm exudate which has covered over the intestines should be noted. The intestines in this region were practically free before the rubber plate was inserted. The plate was removed seven days after its insertion.

rubber inner tube from a large automobile tire was cut so that it would be somewhat larger than the proposed defect. On December 22, with the patient under general anesthesia, the gangrenous area was entirely removed with electric cautery. This area followed under the skin well onto the posterior border of the abdominal wall near the spinal muscles and almost to the axilla. Along the peritoneal margins of the gangrenous area there were weak adhesions between the intestines and the healthy peritoneum; as far as possible, these were undisturbed. Throughout most of the wound, the intestines were unsupported. The piece of thick rubber inner tube of an automobile tire was boiled; it was trimmed in the general shape of the defect

1. Hertzler, A. E.: The Peritoneum, St. Louis, C. V. Mosby Company, 1919, vol. 1, pp. 251-270.

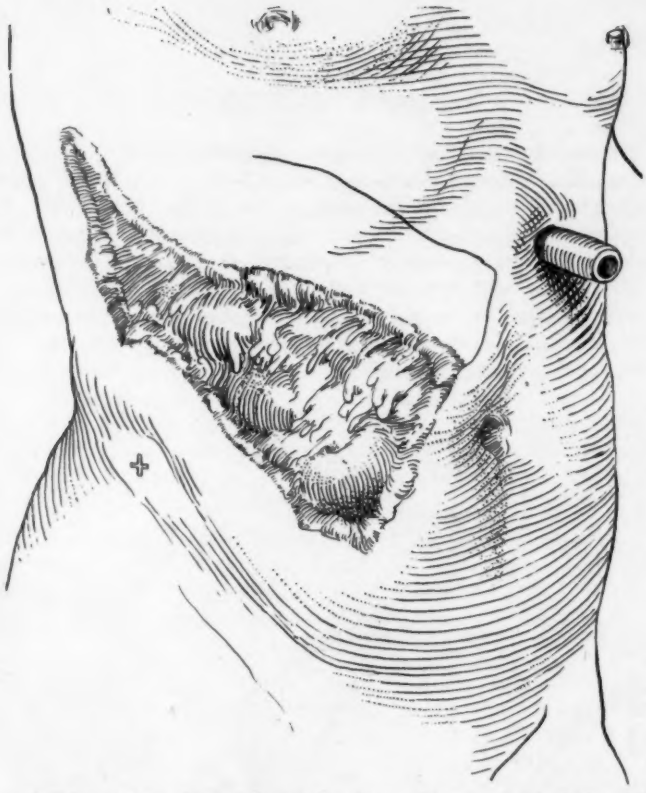

Fig. 8.—Outline of the flap made twelve days after removal of the rubber plate. In the meantime, a gastrostomy had been done.

Fig. 9.—Appearance of the wound twenty-eight days after the flap was transplanted. In order to relieve tension, adhesive plaster was placed over the flap and sutured to the adhesive plaster on the abdominal wall. In this way the circulation was not disturbed by sutures.

and was fastened into it by insinuating the rubber under the margins of the skin and, when possible, under the margins of the muscle as well. The patch was held with mattress sutures of coarse silkwormgut. To support the rubber, three pieces of metal made from malleable copper retractors coated with silver, with holes drilled in each end, were prepared and placed over the rubber, tucked under the margins of the skin and fastened with silkwormgut sutures (fig. 5). A large drainage tube was put in the posterior extremity of the wound where it led up toward the axilla. The incision toward the axilla was loosely closed with a few interrupted sutures of silkwormgut (fig. 6).

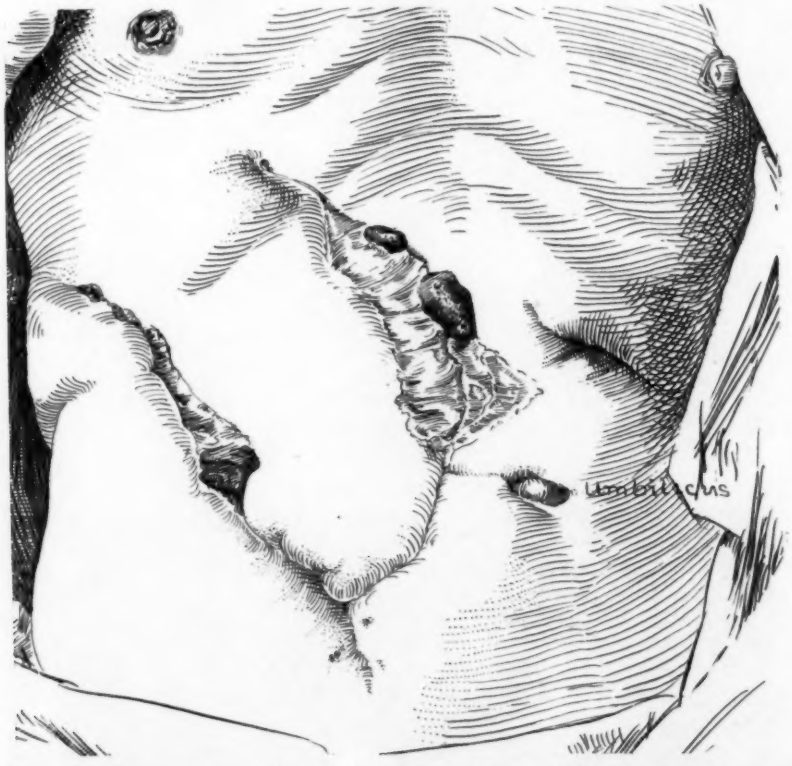

Fig. 10.—Appearance of the abdomen on April 10, 1928, showing the wound almost entirely healed except for a few granulating areas. A few weeks after this, the wound was completely healed. At present there is a small amount of bulging which is easily controlled with an abdominal binder.

The largest piece of necrotic tissue that was removed measured 18 inches (45.7 cm.) in length. It was foul and completely necrotic. Several smaller pieces were also removed.

The patient reacted satisfactorily. Leakage did not occur from the enterostomy wound. The dressings were frequently changed, as there was considerable discharge of pus. Seven days after this operation, the metal pieces and the rubber patch were removed. The intestines were well coated with a thick, fairly firm exudate (fig. 7). It was impossible to secure muscular support for the defect in the abdominal wall, so a pedicle flap was relied on. A long pedicle

flap of skin and subcuticular fat was outlined along the upper margin of the incision with the base posteriorly (fig. 8). This was done in stages so as to throw the vascular supply gradually on the pedicle. Finally, after three operations, the flap was freed, except from its pedicle, and transferred over the raw surface. By undermining the tissues along the inner and lower border of the defect, the skin could be approximated at these points. The flap healed satisfactorily throughout.

The patient, however, developed a sore pharynx, and it was difficult for him to take nourishment. He had been given quanttiies of dextrose in Ringer's solution intravenously until most of his veins had become unavailable for this. If food was pushed he strangled, and there was great danger of pneumonia. Consequently, on Dec. 30, 1927, sixteen days after the first operation and before the flap had been transferred but while it was being prepared, a gastrostomy was done under local anesthesia, the operation being performed while the patient was in bed. Practically all feeding was then given through the gastrostomy opening. The patient began to improve soon after the gastrostomy. The gastrostomy tube was removed about three weeks later. The wound healed quickly. He was discharged from the hospital on Feb. 23, 1928 (fig. 9).

Figure 10 shows his condition in April, 1928. When heard from a few weeks before this article was written, he was in good general health. There was some bulging of the abdominal wall on the right side, though this was well controlled by a supporting belt. He was attending to his ordinary duties.

COMMENT

There are several interesting features about this case. An intussusception in an adult due to a lipoma in the ileum is rare. An intussusception caused by an intestinal tumor is not common, but one caused by a lipoma is extremely rare. Watts [2] reported two cases of intussusception due to tumors—one an adenoma and one a sarcoma—and referred to the literature on the subject. Willis [3] reported three cases of intussusception due to benign tumors of the intestine and also cited references to the literature. Most of these intussusceptions occur in children or infants.

The second unusual feature of the case is the gangrene of the abdominal wall. Instances in which ulceration and certain types of gangrene have followed abdominal operations, particularly when the intestinal tract has been opened, have been fully recorded. One of the most interesting articles is by Brewer and Meleney,[4] in which they described a case of progressive gangrene of the skin and subcuticular tissues following an operation for appendicitis. In some experimental work by these authors, the conclusion was reached that when the

2. Watts, Stephen H.: Intussusception in the Adult, Ann. Surg. **53:** 408, 1911.

3. Willis, A. M.: Intussusception Resulting from Benign Tumor of the Intestine, Surg. Gynec. Obst. **30:** 603 (June) 1920.

4. Brewer, G. E., and Meleney, F. L.: Progressive Gangrenous Infection of the Skin and Subcutaneous Tissues Following Operation for Acute Perforative Appendicitis, Tr. Am. Surg. A. **44:**389, 1926.

nonhemolytic micro-aerophilic streptococcus and the hemolytic *Staphylococcus aureus* from the patient's wound were injected together into guinea-pigs, rabbits and one dog, almost invariably gangrene was produced, but that when these organisms were injected separately gangrene did not occur. There seems to be a symbiotic function or combination of functions of these two organisms, and without it gangrene does not occur. The streptococcus is found more rarely than *Staphylococcus aureus,* and consequently might be more easily overlooked in routine cultures. Cullen of Baltimore, Christopher of Chicago, Alexander of Philadelphia and Moschcowitz of New York have reported somewhat similar cases.

In this case, however, the gangrene was of a somewhat different type. It proceeded not so much as an ulceration, but as a massive death of the tissues in which the skin and subcutaneous tissues were less extensively affected than the muscles. The smear from the wound showed many gram-negative bacilli, a few short chains of streptococci, a few large gram-positive diplococci, a few large gram-positive bacilli and many gram-positive cocci. Cultures from the wound after forty-eight hours in a blood sugar medium showed many diphtheroid bacilli, many small gram-negative bacilli (colon bacilli), a few short chains of streptococci and many gram-positive staphylococci. Cultures in plain agar showed nonhemolytic streptococci, nonhemolytic staphylococci and *Staphylococcus aureus.* Cultures in dextrose broth showed many gram-positive cocci (staphylococci), a few large gram-positive diplococci, occasional short and long chain streptococci, and many small and large bacilli, both gram-negative and gram-positive. Three cubic centimeters of pure mixed culture was injected subcutaneously into a guinea-pig. The guinea-pig died forty-eight hours after the injection. At necropsy the skin, the fascia and the muscles of the abdominal wall showed beginning gangrene with a foul odor. The kidneys, the liver and the lungs showed signs of active congestion. The peritoneal cavity contained some foul smelling, straw-colored fluid. The culture and smears from the guinea-pig showed the same organisms as those already described.

A partial report concerning a culture from the wound taken by Dr. Frederick W. Shaw, professor of bacteriology at the Medical College of Virginia, on Jan. 10, 1928, is as follows: "Genus, *Klebsiella.* The bacterium was capsulated, gram-negative, nonmotile, with reduced nitrates. There was a thin pedicle on Durham's. It was pathogenic for guinea-pigs. This organism would be classified by Perkins as *Bacterium duodenal* Ford."

Obviously the most satisfactory treatment for this gangrene is removal by the electric cautery. An incision with the knife would doubtless open healthy tissue to this infection and, if made, it should be followed at once by some strong cauterizing agent. The endotherm

knife undoubtedly would be helpful in such cases, but because of the close proximity of the bowel it might be dangerous; so, though the endotherm knife was used in the first limited excision, the regular electric cautery was used in removing the large mass of gangrenous tissue. There is also the advantage of greater heat, which would penetrate deeper.

A third interesting feature is the use of the rubber for temporary support of the abdominal wall. After the gangrenous process, it was obvious that it would be only a short time before the patient would become disemboweled, and merely replacing the intestines in the abdomen without a support would have been of little help. Rubber was selected as a temporary support, as already indicated, because of its nonirritability and because it was readily available. The section from an inner tube proved effective. On the under surface, next to the peritoneal cavity, an exudate membrane rapidly formed. While the exudate was still thick but after the wound was clean, a plastic operation was readily accomplished.

Another feature of some interest is the gastrostomy which was utilized to feed the patient, to avoid bronchopneumonia and to give rest to the throat.

SUMMARY

A case is reported in which an operation was performed on an elderly man for intussusception apparently due to a lipoma of the ileum. Massive gangrene of the abdominal wall followed, necessitating excision of the gangrenous tissue and temporary repair of the abdominal wall with a section of an inner tube from an automobile tire. Later, a plastic operation was performed. On account of painful pharyngitis, a gastrostomy was done.

PRIMARY GIANT CELL TUMOR OF THE PATELLA*

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AND
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Giant cell sarcoma was apparently first recognized in 1845 by Lebert.[1] Paget,[2] in 1853, and Nelaton,[3] in 1860, described this lesion, and Robin,[4] in 1850, described benign tumors of bones containing large giant cells, which he identified with marrow giant cells. In 1879, Gross [5] analyzed seventy cases of giant cell sarcoma, describing their features and emphasizing their benign nature.

In America, the giant cell tumors were not regarded as malignant until 1910 when Bloodgood emphasized their benign character. In 1920, he [6] reported forty-seven cases in none of which metastasis had occurred. In 1920, Codman [7] established a general registry for bone sarcoma which stimulated interest in tumors of the bone, but the actual etiology and pathogenesis have never been worked out. Codman stated that over a hundred cases of giant cell tumor had been registered without a true case of metastasis. Chatterton and Flagstad,[8] in 1927, reported two cases of giant cell tumor which, although microscopically benign, developed changes suggestive of malignancy. They stated in conclusion: "These two cases, with others reported, suggest that at times difficulty and peculiarity are encountered in diagnosis and behavior of giant-cell tumors." Coley [9] from a study of fifty cases, in nine of which metastasis had occurred, concluded that occasionally a frank giant cell tumor may

* Submitted for publication, Nov. 30, 1928.

* From the John Rogers Hegeman Memorial Laboratory, Metropolitan Life Insurance Company Sanatorium, McGregor, N. Y., and the Saratoga Hospital.

1. Lebert: Physiol. Path. **2**:120, 1845.
2. Paget: Surg. Path., 1853.
3. Nelaton: Tumeurs a myelopaxes, Paris, 1860.
4. Robin: Soc. Biol., 1849-1850.
5. Gross, S. W.: Am. J. M. Sc. **78**:17, 1879.
6. Bloodgood, J. C.: J. Radiol. **1**:147, 1920.
7. Codman, E. A.: Bone Sarcoma, New York, Paul B. Hoeber, 1925.
8. Chatterton, C. C., and Flagstad, A. E.: J. Bone & Joint Surg. **25**:111, 1927.
9. Coley, W. B.: Ann. Surg. **79**:561, 1924.

undergo changes of a malignant type. In 1927, he [10] reported a follow-up of these fifty cases and included nineteen new ones. He concluded: "Giant-cell sarcoma, or 'giant-cell tumor' as it is designated by most pathologists today, while in the great majority of cases, a benign or at least only locally malignant lesion, should still be classed as a sarcoma since in certain cases it has all the clinical features of a malignant bone tumor causing death by metastases." Cole [11] stated that "giant-cell tumors can be cured by curettement and local recurrence prevented by cauterization of the cavity thus formed with pure carbolic acid followed by alcohol." Stone and Ewing [12] held that rarely, if ever, does a true giant cell tumor metastasize. They said, "There is no satisfactory record of metastasis of a giant-cell tumor in its original form."

Several hundred cases of giant cell tumors have been reported in the literature, a small group of which have been multiple. The latter were considered by Alexander and Crawford.[13] Christensen [14] listed 1,000 cases of tumors of the bone, but recorded only one primary tumor of the patella in this group—a malignant osteogenic type. Thus it is seen that single primary tumors of the patella are extremely rare. Cole,[11] in 1925, reported the first benign cyst of the patella. He found this the twenty-fifth patellar tumor recorded. This series of twenty-five tumors of the patella included all the common tumors of bone, except myxoma. In fourteen of twenty-one of these cases in which information was available, there was a history of trauma. The injury to the patella had occurred from about two months to several years previous to the development of the tumor. There is on record another case of patellar tumor not included in Cole's list of twenty-five. It was reported in 1924 by R. Faltin [15] as a giant cell tumor of the patella. His patient had for five years had a tumor that destroyed the patella. The tumor was enucleated and the cavity scraped out. After a few months there was a regeneration of the patella. Microscopically, it could be ascertained that the tumor tissue, which was rich in cells and contained giant cells, was continuously differentiated into connective or scar tissue which was

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10. Coley, W. B.: Ann. Surg. **86**:641, 1927.

11. Cole, W. H.: J. Bone & Joint Surg. **7**:637, 1925.

12. Stone, W. S., and Ewing, J.: An Unusual Alteration in the Natural History of a Giant Cell Tumor of Bone, Arch. Surg. **7**:280 (Sept.) 1923.

13. Alexander, E. G., and Crawford, W. H.: Ann. Surg. **86**:362, 1927.

14. Christensen: Ann. Surg. **81**:1074, 1925.

15. Faltin, R.: Acta chir. Scandinav. **58**:36, 1924.

poor in cells and did not contain any giant cells. He would not declare the tumor a true blastoma but thought that it was rather a condition belonging to osteitis fibrosa localisata.

The following is the report of a case on the surgical service of the Saratoga Hospital.

Fig. 1.—Section of the tumor showing chronic inflammation and giant cells; ×65.

REPORT OF CASE

A well developed and well nourished man, aged 19, consulted the surgeon because of a "swollen knee and difficulty in getting about." He said that his illness had begun about two months previously, when he fell and struck his left knee on a sidewalk. He noticed that the swelling and lameness developed soon after the fall. Four weeks before the accident, he had an attack of "septic sore throat," from which he made a complete recovery in two weeks. Physical examination on admis-

sion to the hospital showed the left knee reddened, with considerable swelling and sensitiveness over the patella. The results of the physical examination were otherwise essentially negative. A history of venereal disease or of tuberculosis was not elicited, and the Wassermann reaction of the blood was negative.

A roentgenogram of the knee at this time was reported on by Dr. Earl King as follows: "There is a rarefied condition of the lower two-thirds of the patella

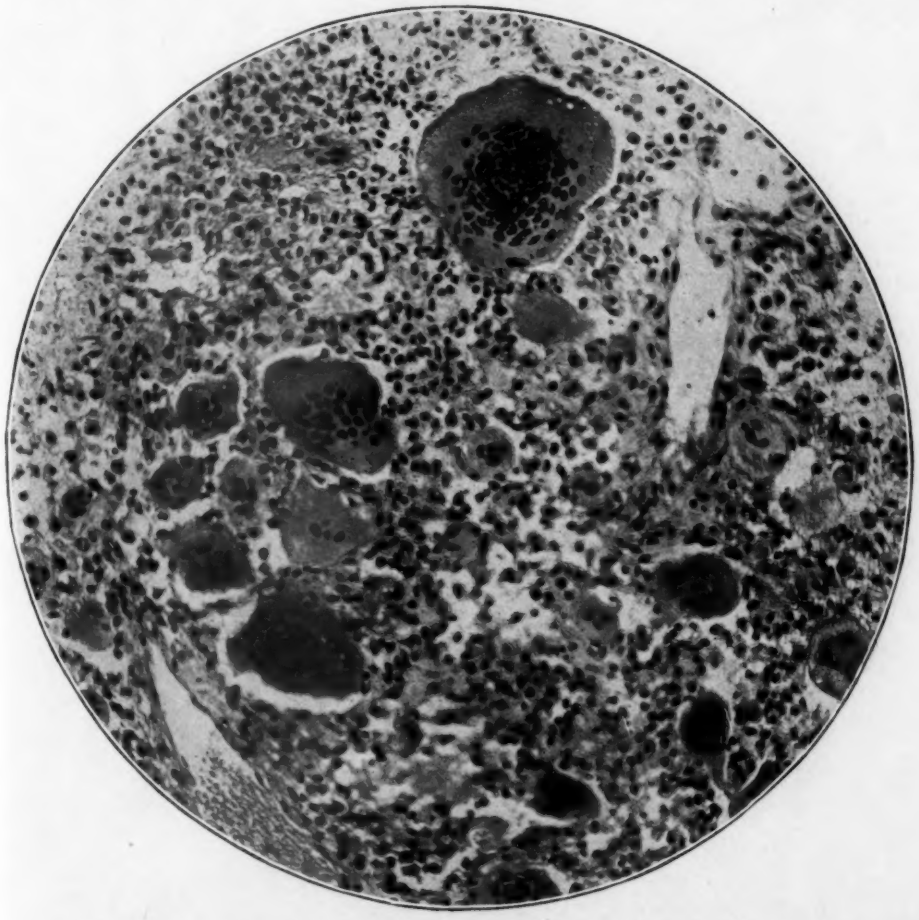

Fig. 2.—Same section shown in figure 1, with higher magnification; × 210.

with destruction of the periosteum and débris about and below the bone. Interpretation—bone tumor, probably giant-cell sarcoma."

On May 8, 1926, an operation was performed, and practically all but the shell of the patella was removed. The cavity was curetted and thoroughly packed with gauze. The wound healed by granulation. The material removed with the curet, which was of a granular, friable, vascular type, was fixed in formaldehyde and sent to the Hegeman Memorial Laboratory for diagnosis.

Microscopic examination of the tissue, which was sectioned in paraffin and stained with Mallory's eosin-methylene blue, showed many fine capillaries with

numerous proliferating endothelial cells intermingled with a spindle cell stroma. In some sections, the bulk of the tumor was composed of small and large giant cells; the large ones contained numerous small separate nuclei and enclosed detritus, blood cells, lipoid material and bone spicules. In other foci, the giant cells were less frequent. These cells clearly resembled the foreign body giant cells of Mallory,[16] which he regarded as arising by the fusion of endothelial leukocytes.

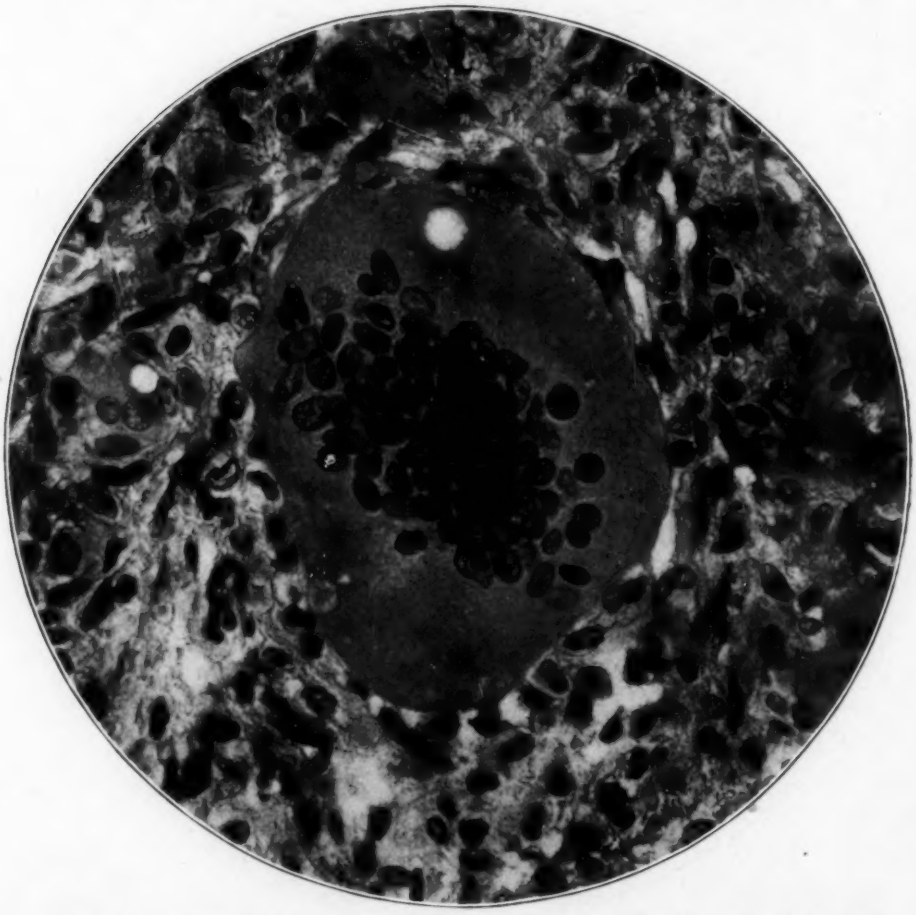

Fig. 3.—Single giant cell showing arrangement of the nuclei and phagocytosed material in the cytoplasm; × 525.

The cytoplasm was abundant and sharply defined and stained deeply with acid stain. The nuclei were uniform, without mitoses, and were often clustered near the periphery of the cell. These giant cells resembled osteoblasts and apparently were called into the tissue in response to the presence of foreign bodies resulting from the destruction of bone.

In February, 1928, two years after the operation, the patient was well and was working every day, with normal use of the left knee. There was a linear

16. Mallory, F. B.: J. M. Research **24**:463, 1911.

scar in a perpendicular position over the left patella. The skin was not adherent to the underlying tissues and bone, but there was an indentation on the outer surface of the patella in a line parallel to the scar and directly beneath it. There was apparently a bony exostosis extending from the lower border of the bone, but the

Fig. 4.—Roentgenogram taken before the operation, showing rarefaction of the lower two thirds of the patella with destruction of the periosteum.

Fig. 5.—Roentgenogram taken two years after the operation, showing a recurrence of the rarefaction and an exostosis extending from the lower surface of the patella.

knee joint functioned properly. Gait was not impaired. Roentgenograms at this time showed an apparent rarefaction in the lower half of the patella and an exostosis extending down the sheath from the lower margin. There had undoubtedly been some local recurrence of the tumor.

CONCLUSIONS

A case of primary giant cell tumor of the patella is reported. Two years after curettement, the patient was well and did not notice any impairment of function of the knee joint. A roentgenologic recurrence occurred after two years, which should readily yield to curettement and cauterization.

CHOLECYSTOGASTROSTOMY

AN EXPERIMENTAL STUDY *

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According to the literature, Oddi [1] was probably the first to perform cholecystogastrostomy experimentally in an attempt to discover the effect of bile on gastric acidity. He concluded that bile did not diminish the power of the gastric juice or cause disturbances. Dastre,[2] Cannac [3] and Masse [4] performed similar experiments and arrived at the same conclusions. Mocquot,[5] Wiedemann [6] and Grey [7] performed cholecystogastrostomy on dogs and studied the effect of bile on gastric digestion. Grey also studied the acidity of the gastric juice before and after this operation. They all concluded that bile did not affect gastric digestion in any way, and Grey found that it did not affect the acidity. Gatewood and Poppens,[8] Lehman,[9] Marinelli [10] and Horsley [11] performed chole-

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* Work done in Division of Experimental Surgery and Pathology.

1. Oddi, Ruggero: Action de la bile sur la digestion gastrique étudién au moyen de la fistule colécisto-gastrique, Arch. ital. de biol. **9**:138, 1888.

2. Dastre, A.: Recherches sur la bile, Arch. de physiol. norm. et path. **2**:315, 1890.

3. Cannac, L. B.: De la cholécystogastrostomie, Thèse, Bordeaux, 1897, p. 62.

4. Masse, E.: De la cholécystogastrostomie, Gaz. hebd. d. sc. méd. de Bordeaux **19**:534, 1898.

5. Mocquot, Pierre: Anastomosis de la vesecule biliaire avec l'estomoc et avec le duodenum, Compt rend. Soc. de biol. **2**:118, 1911.

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7. Grey, E. G.: An Experimental Study of the Effect of Cholecystgastrostomy on Gastric Acidity, J. Exper. Med. **33**:15, 1916.

8. Gatewood, and Poppens, P. H.: Cholecystenterostomy from an Experimental Standpoint, Surg. Gynec. Obst. **35**:445, 1922.

9. Lehman, E. P.: Hepatitis, Following Cholecystogastrostomy, Arch. Surg. **9**:16 (July) 1924.

10. Marinelli, F.: Anastomosis Between Gallbladder and Gastro-Intestinal Tract, abstr., J. A. M. A. **85**:1592 (Nov. 14) 1925.

11. Horsley, J. S., Jr.: Experimental Study of Cholecystogastrostomy and Cholecystoduodenostomy, South. M. J. **20**:669, 1927.

cystogastrostomy on dogs, and studied its effect on the biliary tract and liver. They concluded that the biliary tract always became infected following this operation.

It is apparent from the literature that the use of cholecystogastrostomy is extending; it is now being utilized for many purposes other than irreparable obstruction of the common bile duct. As is well known, diversion of bile into the stomach apparently does not cause digestive disturbances, and in many instances definitely benefits the patient. The clinical evidence that bile is well tolerated in the stomach probably originated with Wickhoff and Angelberger [12] who are given credit for having performed the first anastomosis of this kind on man.

Terrier,[13] Monod,[14] Jaboulay,[15] Montognon and Duchamp [16] each reported a case in which the reaction was favorable following cholecystogastrostomy. Perrin [17] discussed the operation; he attributed the progress in its use to the early experimental investigators, and concluded that the operation is both anatomically and physiologically rational, and easily and rapidly performed. Eichmeyer [18] and Kehr [19] reported many favorable cases of cholecystogastrostomy from the clinic of Professor Hans Kehr of Holberstadt. Jacobson [20] and Erdmann [21] pointed out that this operation should be the one of choice whenever it became necessary to short-circuit the bile, because of the lessened likelihood of ascending infection of the biliary tract and because the digestive function of the bile and the bile salts was preserved. White [22] reported three cases in which

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12. Wickhoff, M., and Angelberger, F.: Cholelithiasis; obduratio ductus choledochi (?), Cholecysto-gastrostomie; Heilung, **6**:325, 1893.

13. Terrier, M.: Sur un cas de gastrocystèntérostomie, Bull. et mém. Soc. de chir. de Paris **22**:565, 1896.

14. Monod, M.: Suite de la discussion sur la choledocotomie, Bull. et mém. Soc. de chir. de Paris **22**:546, 1896.

15. Jaboulay, M.: La cholecystogastrostomie pour les tumeurs de la tête du pancréas, Lyon méd. **89**:365, 1898.

16. Montognon and Duchamp: Obstruction neoplastique de choledoque. Abouchment de la vesecule dans l'estomoc, Loire méd. **18**:142, 1899.

17. Perrin, F. H.: La cholécystogastrostomie dans l'occlusion supposée complète et directement irrémédiable du cholédoque, Thèse, Lyon, p. 169, 1902.

18. Eichmeyer, Wilhelm: Beiträge zur chirurgie des Choledochus und Hepaticus einschlusslich der Anastomosen zwischen Gallensystem und Intestinis, Arch. f. klin. Chir. **93**:857, 1910; **94**:1, 1911.

19. Kehr, Hans: Die Praxis der Gallenwege-Chirurgie in Wort und Bild, München, J. F. Lehmanns, Vols. 1 and 2, 1913. Kehr, Hans: Die gut- und bösartigen Neubildungen der Gallenblase und der Gallengänge unter besonderer Berücksichtigung eigener Erfakrungen, Ergebn. d. Chir. u. Orthop. **8**:471, 1914.

20. Jacobson, J. H.: Anastomosis of the Gallbladder to the Stomach: "Cholecystogastrostomy," Tr. Am. A. Obst. **27**:172, 1914.

21. Erdmann, J. F.: Obstructive (malignant) Jaundice: Operative Relief by Cholecystogastrostomy, Ann. Surg. **67**:273, 1918.

22. White, C. S.: Cholecystogastrostomy, Surg. Gynec. Obst. **31**:493, 1920.

the operation had been used successfully and pointed out the simplicity of technic and the absence of danger of ascending infection.

Babcock [23] and Heyd [24] recommended wider use of cholecystogastrostomy and both believed the operation to be a rational one for gastric ulcer. Babcock advocated the anastomosis of the gallbladder directly into the ulcerated area as a substitute for gastro-enterostomy; he also believed the operation to be preferable to drainage of the gallbladder.

Mayo,[25] Moore,[26] Ralphs,[27] Downes,[28] Stretton,[29] McNealy [30] and Murdy [31] reported favorably on the use of cholecystogastrostomy in the presence of irreparable obstruction of the common bile duct due to the malignant lesions, stricture or other causes. Murdy suggested that the operation could well be used in place of cholecystectomy for infection of the gallbladder without stones, or for cholangeitis with or without stones.

DuBose [32] reported favorable results in many cases of cholecystogastrostomy. He recommended much wider use of the operation to include cases of perforated gastric and duodenal ulcers, perforation of the gallbladder and obscure chronic or intermittent jaundice. He did not believe there was danger of infection of the biliary tract and liver following this operation. Deaver [33] stated that cholecystogastrostomy was a better operation than drainage, for it prevented the loss of bile salts and fluids. Frenkel [34] treated twenty-one patients with peptic ulcer by this operation. He noted a decrease in the total and free acid content after

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23. Babcock, W. W.: Cholecystogastrostomy and Cholecystoduodenostomy, Am. J. Obst. & Gynec. **1**:854, 1920-1921.

24. Heyd, C. G.: Cholecystogastrostomy and the Courvoisier Gallbladder, J. A. M. A. **77**:339 (July 30) 1921.

25. Mayo, C. H.: Jaundice and Its Surgical Significance, Surg. Gynec. Obst. **30**:545, 1920.

26. Moore, C. A.: A Case of Cholecystogastrostomy, Brit. M. J. **2**:826, 1921.

27. Ralphs, Gerald: The Operation of Cholecystogastrostomy, Brit. M. J. **1**:14, 1922.

28. Downes, W. A.: Chronic Obstructive Jaundice: A Report of Nine Cases Treated by Cholecystogastrostomy, South. Surg. Tr. **35**:342, 1922.

29. Stretton, J. L.: Cholecystogastrostomy, Brit. M. J. **2**:600, 1922.

30. McNealy, R. W.: Operative Case: Obstructive Jaundice, Journal-Lancet **43**:636, 1923.

31. Murdy, R. L.: Indications for Cholecystenterostomy, Journal-Lancet **43**:89, 1923.

32. DuBose, F. G.: Cholecystogastrostomy and Cholecystoduodenostomy, Surg. Gynec. Obst. **39**:295, 1924; Cholecystogastrostomy, South. M. J. **20**:674, 1927.

33. Deaver, J. B.: Cholecystectomy: External and Internal Cholecystostomy, Ann. Surg. **81**:761, 1925.

34. Frenkel, A.: Der Einfluss der Cholecystogastrostomie auf den Magenchenismus beim Magen- und Duodenal-ulcus, Zentralbl. f. Chir. **52**:1459, 1925; abstr., J. A. M. A. **85**:711 (Aug. 29) 1925.

the operation and considered this to be the therapeutic factor. Braithwaite [35] and Nazarov [36] reported cases of peptic ulcer in which the reaction was favorable following cholecystogastrostomy. Nazarov reported a constant decrease in gastric acidity following this operation. Villard and Richer [37] preferred cholecystogastrostomy above other methods of anastomosis because of the ease of technic and the lack of digestive disturbances. Muller [38] presented case histories in which this operation had been performed successfully. Walters [39] pointed out that the operation is most useful in cases of obstructive jaundice due to stricture of the common bile duct, pancreatitis or carcinoma of the head of the pancreas. Weinberg, Wallin and Binger [40] reported a case of cholecystogastrostomy in which recovery was uneventful. Fifteen days after the operation chemical tests of the gastric acidity were found to be negative. To explain this result, the operation was performed on dogs, and specimens of the gastric contents were collected through gastric fistulas. They did not find a change in acidity. Postmortem examinations of the dogs showed infection of the gallbladder and abscesses throughout the liver.

METHOD OF RESEARCH

Two series of six dogs each were studied. The animals were normal and healthy and weighed between 7 and 10 Kg. Prior to operation, numerous analyses of the gastric contents were made on all of the dogs in the first series to establish a normal curve of the total and free hydrochloric acid and the total chlorides. Fractional gastric analysis was carried out. The specimens of the gastric contents were removed from the stomach at intervals of fifteen or thirty minutes by means of a large stomach tube and a suction apparatus. The dogs quickly become accustomed to the tube, and do not manifest discomfort from its use. After a few days, if the dog has been gently handled and trained, he will not have the slightest psychic disturbance which might upset gastric digestion.

For the test meals raw horse meat (ground three times) was used. The standard meal was 80 Gm. of meat thoroughly mixed with 250 cc. of water. It was found that such a meal could be withdrawn through the stomach tube readily, and that it did not unduly prolong the period of gastric digestion. The dogs were placed on a fast for twelve hours before the test meal was placed in their cage, and it was found that healthy dogs would eat it immediately. Samples of the gastric content were then removed every half hour until free acid appeared, after which

35. Braithwaite, L. R.: Surgical Treatment of Chronic Duodenal and Gastric Ulcer: Cholecystogastrostomy as the Operation of Choice for Inaccessible Gastric Ulcer, Lancet **1**:900, 1926.

36. Nazarov, N. N.: Cholecystogastrostomy for Gastric Ulcer, Surg. Gynec. Obst. **45**:474, 1927.

37. Villard and Richer: La cholécysto-gastrostomie, Rev. de chir. **63**:455, 1925.

38. Muller, G. P.: Cholecyst-duodenostomy, Ann. Surg. **84**:95, 1926.

39. Walters, Waltman: Cholescystgastrostomy, Surg. Gynec. Obst. **42**:825, 1926.

40. Weinberg, J. A.; Wallin, S. P., and Binger, M. W.: Gallbladder-Stomach Anastomosis, Surg. Gynec. Obst. **45**:795, 1927.

the samples were removed every fifteen minutes until the free acid disappeared. The free and total acid was titrated against tenth normal sodium hydroxide, dimethylamedoazobenzol and phenolphthalein being used as indicators. The total chlorides were determined by the Folin method.

Roentgen-ray and fluoroscopic studies of the emptying time of the stomach before operation were also carried out in dogs of the first series. Fifteen grams of barium per kilogram of body weight was mixed with an equal amount of condensed milk and acacia. A roentgenogram was taken immediately on ingestion of the motor meal to determine the normal outline of the stomach. The emptying process was then watched under the fluoroscope, and when the stomach appeared to be empty, another roentgenogram was taken. Usually a third picture was taken from a half hour to an hour later.

After completion of the preliminary studies of the dogs in the first series, cholecystogastrostomy was performed under full ether anesthesia with strictly aseptic technic. The suture method of anastomosis was used in all cases; clamps were not used at any time. The technic is essentially the same as that in gastroenterostomy by the suture method. In most cases the approximation of the gallbladder and the stomach was easily accomplished, and the anastomosis did not result in undue tension on the gallbladder. The common bile duct was doubly ligated and incised in each case.

Chemical changes were not observed in the second series of dogs, but the same operation was performed as in the first series. The purpose of the second series of experiments was to determine whether or not pathologic changes occurred in the biliary tract and liver following this type of operation. After the animals had recovered from the operation completely they were returned to their normal diet and conditions of living for varying periods. Exploration was then performed, and sections of the gallbladder, liver and stomach were removed for microscopic examination.

In the first series, two sites of anastomosis between the gallbladder and stomach were selected. In three animals, the gallbladder was anastomosed to the pyloric segment about 2 cm. above the pyloric valve and midway between the lesser and greater curvatures; in the other three, the gallbladder was anastomosed to the fundus of the stomach midway between the lesser and greater curvatures. This was done to prevent any possibility of the bile being swept out of the stomach before it was thoroughly mixed with the gastric contents.

After sufficient time had been allowed for complete recovery from the operation and satisfactory healing of the abdominal wound, fractional gastric analysis was repeated on each dog in the first series. It was customary to allow from ten days to two weeks to elapse before these chemical studies were repeated. Thereafter, at least one complete fractional analysis was made each week for a month and from then on at longer intervals.

The emptying time of the stomach was studied after operation by the same technic as that used before operation.

RESULTS

All the dogs recovered from the operation, and the wounds healed by first intention. Without exception, the dogs remained in excellent condition and gained weight on a diet of milk and syrup.

The normal curves for the free and total acid and total chlorides before operation were somewhat as follows:

The first sample removed from the stomach did not show free acid but total acid of from 20 to 25, and total chlorides of about from 70 to 80 mg. chlorine for each 100 cc. Samples were removed every half hour until free acid appeared, usually at the end of an hour or an hour and a half. By the time free acid appeared, the total acid had reached from 80 to 100 and the total chlorides from 180 to 240 mg. chlorine for each 100 cc. After the appearance of free acid, samples were removed every fifteen minutes until it disappeared. The free acid was found to rise from 20 to 60, and then to decrease in a gradual curve. After operation, the curves were essentially the same with the exception that free acid usually appeared more quickly, and the total chloride curve usually rose higher.

The postoperative studies of the chemical changes in the first series of dogs showed free and total acid to be present in essentially the same

A Synopsis of the Protocols of the Six Dogs in the First Series

Dog	Time	Emptying Time, Hours	Total Acid			Free Acid			Total Chlorides		
			Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
1	Preoperative	3.5 to 4.0	98	10	94	54	18	40.0	3.1	0.3	2.8
	Postoperative	3.5 to 4.0	106	4	98	44	10	42.5	3.1	0.5	2.9
2	Preoperative	3.0 to 3.5	98	10	89	36	10	33.0	3.1	0.7	2.9
	Postoperative	3.0 to 3.5	100	15	80	44	5	32.0	3.5	0.8	3.1
3	Preoperative	3.0 to 3.5	104	20	103	50	20	44.0	3.5	0.6	2.8
	Postoperative	3.5 to 4.0	112	22	87	50	8	41.6	3.5	0.5	3.2
4	Preoperative	3.0 to 3.5	128	4	100	66	10	48.6	3.1	0.4	2.8
	Postoperative	2.75 to 3.0	112	24	101	44	10	42.0	3.3	0.5	2.9
5	Preoperative	3.5 to 4.0	90	6	70	32	10	24.0	2.5	0.5	2.1
	Postoperative	3.5 to 4.0	100	10	87	50	4	37.0	3.1	0.7	2.8
6	Preoperative	3.0 to 3.5	96	10	90	52	12	46.0	3.1	0.5	2.9
	Postoperative	3.0 to 3.5	100	22	92	48	10	44.0	4.5	0.6	3.7

degree as before operation. In every case, there was a slight rise in the amount of total chlorides after operation. Some dogs showed more free and total acid after operation than before; others showed slightly less, thereby indicating that this slight variation is insignificant. As might be expected, the degree of biologic variation in this type of work is considerable; thus the curves for total acid and free acid on normal dogs were found to vary as much as 10 or 15 on different days. A dog was not found who showed free acid at one time and not at another, but dogs without free acid when given the standard meal consistently showed the same result. As the dogs selected for this experiment secreted much free acid, and since enough analyses had been performed preoperatively to give an accurate curve of normal gastric acidity, it seems justifiable to conclude that the bile did not have any effect on this function. The accompanying table shows a synopsis of the protocols of the six dogs in the first series. Figures 1 and 2 are typical of the preoperative and postoperative studies of the chemical changes.

It was noted that every sample aspirated postoperatively was heavily stained with bile. The bile was easily apparent macroscopically, and its presence was confirmed repeatedly by the microscope and the van den Bergh test. There can be no doubt that bile was getting into the stomach and was mixing with the gastric contents. In spite of this, some of the most heavily bile-stained samples showed the greatest amount of free acid.

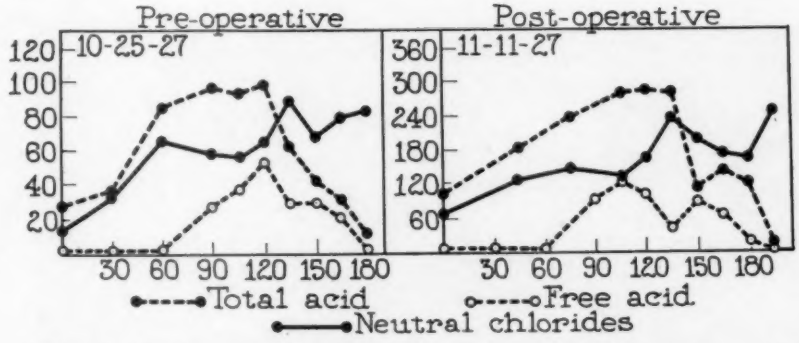

Fig. 1.—Studies of gastric digestion before and after cholecystogastrostomy. The height of the curves for total acid and free acid is essentially the same after operation as before. The curves for total chlorides are practically identical.

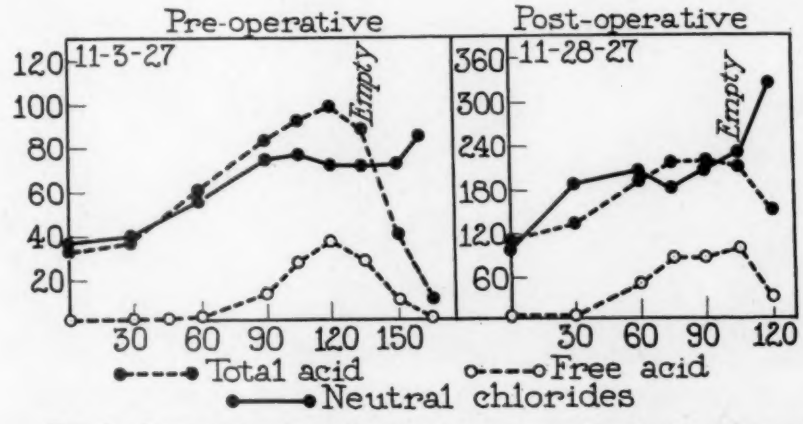

Fig. 2.—Studies of gastric digestion before and after cholecystogastrostomy from another dog in the first series. The free acid appears half an hour earlier after operation, and the height of the curves is identical. The total acid curve is not so high after operation as before, but the variation in all these curves is well within normal limits.

The emptying time of the stomach was not changed by the operation. Immediately after operation the emptying time seemed accelerated, but after the dog had fully recovered, there was essentially no change. One dog, that had apparently recovered entirely, died suddenly thirty-two

days after operation. Fortunately, however, three complete postoperative studies of gastric digestion had been made. At postmortem examination, the anterior surface of the liver was found to be studded by multiple grayish spots having the gross appearance of miliary abscesses. The diaphragm was firmly adherent to the right lobe of the liver, and when this was removed an abscess about 2 cm. in diameter was found. The wall of the gallbladder was thick and grayish. The lungs were

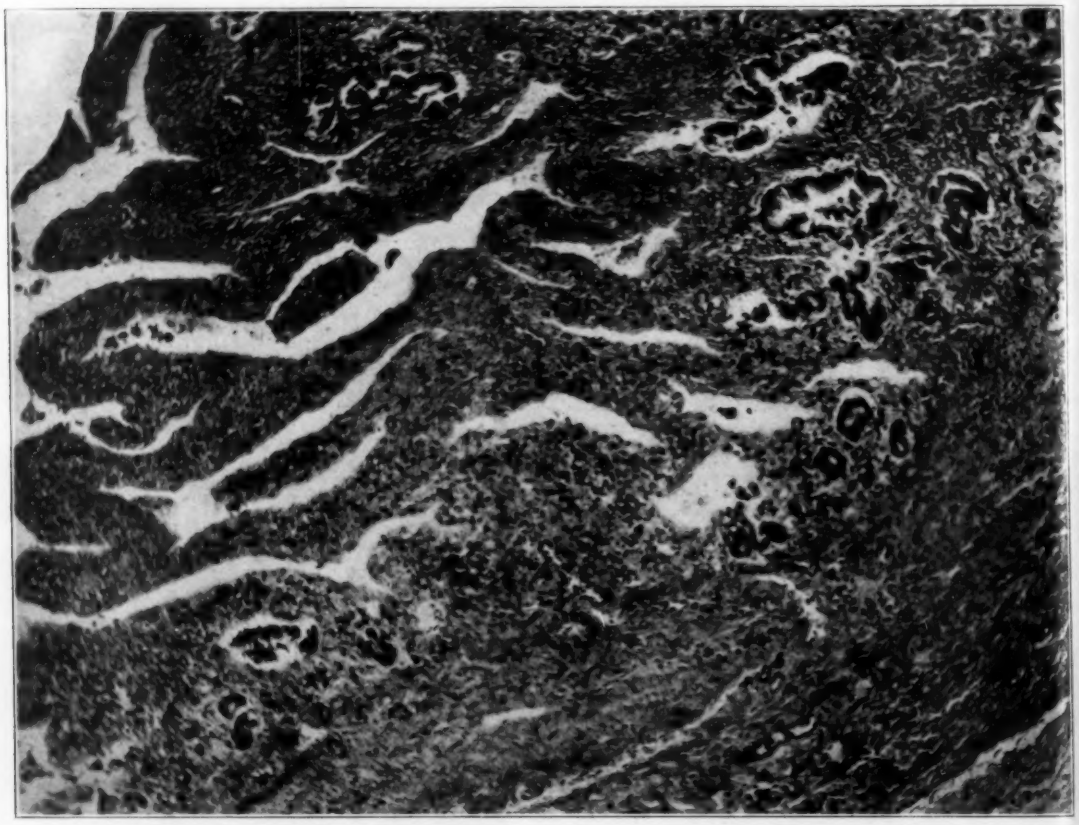

Fig. 3.—Section of the wall of the gallbladder from a dog in the first series, showing marked thickening by fibrous connective tissue and heavy infiltration of large and small lymphocytes.

markedly congested and showed evidence of patchy consolidation. There was no evidence of peritonitis, and healing had taken place at the point of anastomosis without leakage or infection. Microscopic examination of sections taken from the liver revealed acute purulent hepatitis, chiefly periportal. The bile ducts did not show evidence of inflammation; their epithelium was intact, and there was only slight fibrosis around the walls. The wall of the gallbladder was thickened by an increase in fibrous con-

nective tissue but did not show evidence of acute inflammation. Sections of the mucosa of the stomach showed slight round cell infiltration, but the epithelium was intact. The cause of death was attributed to acute purulent hepatitis with abscess formation and secondary bilateral bronchopneumonia (figs. 3, 4 and 5).

The dogs in the second series were explored at varying periods after the first operation, and sections were removed from the gallbladder, liver

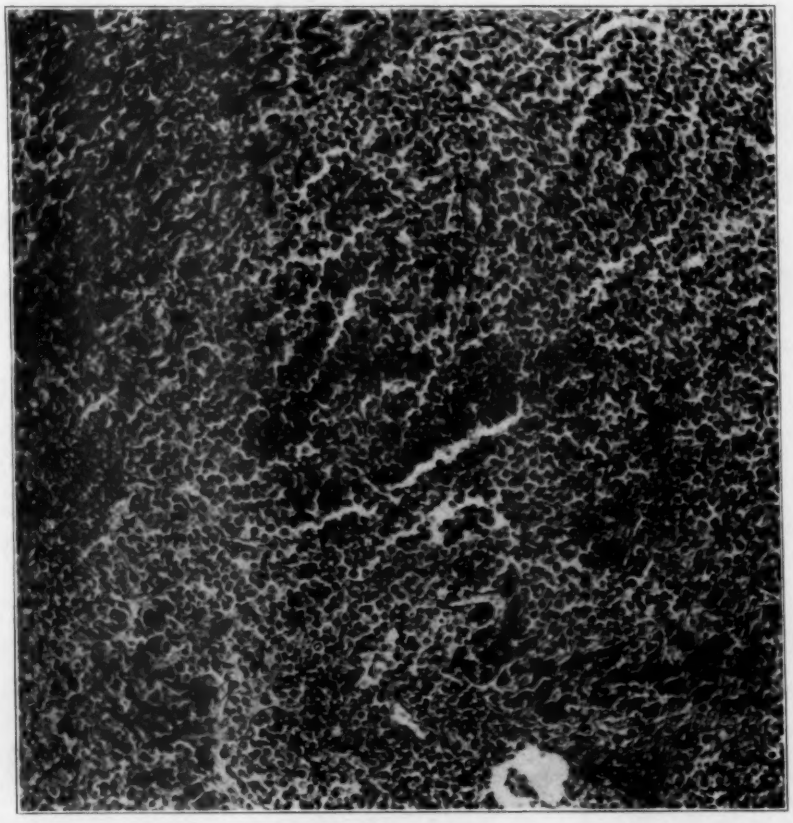

Fig. 4.—Section of liver from a dog in the first series, showing acute purulent hepatitis with marked destruction of the cells of the liver.

and stomach, for microscopic examination. In all the dogs in this series, regardless of the time since operation, inflammatory changes developed in the liver and gallbladder (figs. 6 and 7). These changes varied from slight round cell infiltration with replacement by fibrous connective tissue to acute purulent inflammation with extensive destruction, necrosis and abscess formation. In some of the dogs in which exploration was done a short time after operation, the gallbladder and liver appeared

unchanged grossly. When sections were made and examined, however, definite pathologic changes were found.

COMMENT

The results obtained from the experiments on the first series of dogs verify those of other investigators. It should be noted, however, that

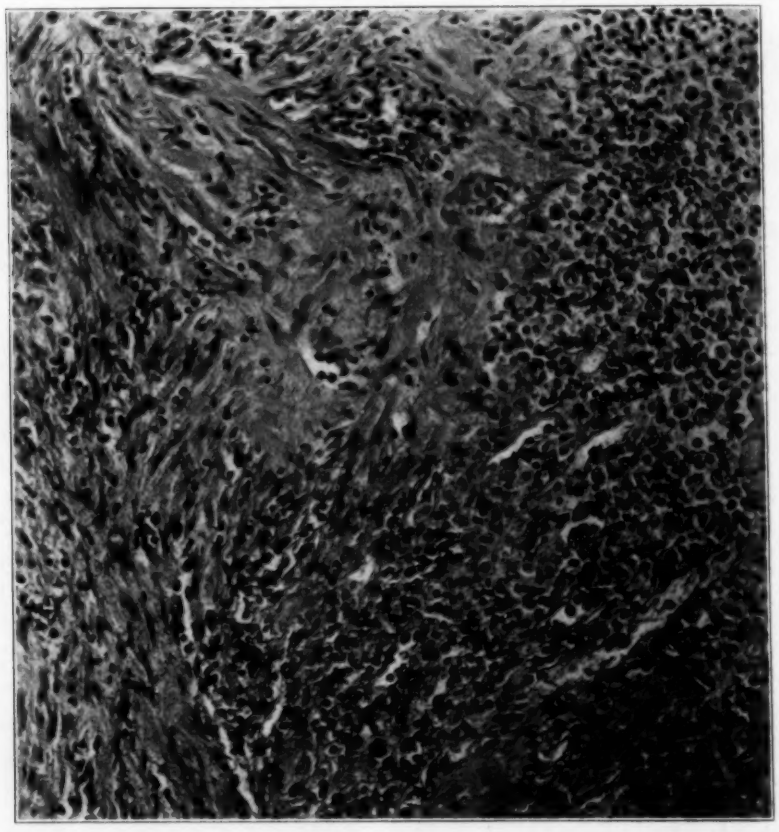

Fig. 5.—Section of the liver from a dog in the first series, showing acute purulent hepatitis with replacement by fibrous connective tissue in an attempt at healing.

the experiments were performed on dogs with intact gastric mechanism. The technic of performing fractional gastric lavage on dogs as worked out by McCann [41] obviates the necessity of resorting to surgical measures on the stomach in order to obtain the gastric samples. The Pavlov pouch has been used for this type of experimentation but is probably not physiologically perfect, since a large portion of the stomach is separated

41. McCann, J. C.: Personal communication to the author.

into the formation of a pouch. This, in all probability, disturbs the secretory and motor activity of the stomach and may result in a certain amount of independent activity of the stomach apart from the pouch. There can be no doubt that in performing the operation a large part of the nerves going to the pouch are injured. The coordinating mechanism is consequently impaired.

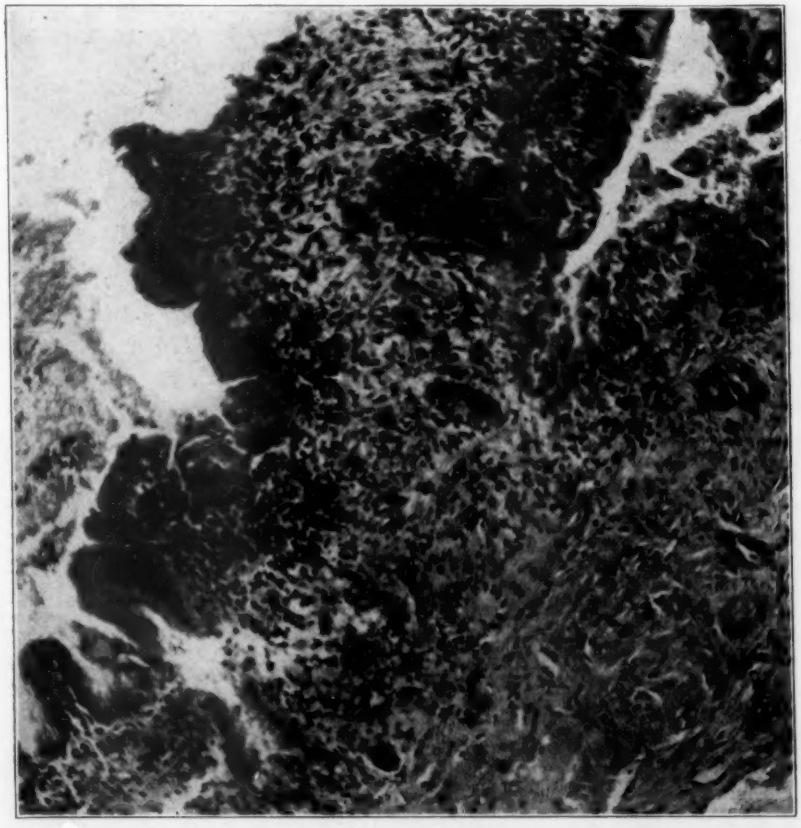

Fig. 6.—Section of the wall of the gallbladder from a dog in the second series, showing marked thickening and round cell infiltration.

Clinically, it is apparent that the operation of cholecystogastrostomy has been gaining favor not only as a means of side-tracking the bile in the presence of irreparable obstruction of the common bile duct, but also as a means of treating lesions as follows: (1) chronic peptic ulcers, (2) hyperacidity with pylorospasm, (3) perforated gallbladders, (4) acute pancreatitis and (5) diabetes in the young with symptoms of biliary obstruction. It may also be used as a substitute operation for cholecystostomy and cholecystectomy. The operation has been recom-

mended, not only because of the ease and rapidity of the technic in comparison with that of gastro-enterostomy and partial resection, but also because of the belief that the bile would actually tend to neutralize the gastric contents. It has been shown many times that the introduction of bile into the stomach does not result in disturbances of digestion. I am in entire agreement with this conclusion. The dogs operated on did not show evidence of gastric disturbance at any time afterward. Many

Fig. 7.—Section of the liver from a dog in the second series, showing periportal round cell infiltration with increase in fibrous connective tissue.

reports are at hand concerning the excellent results obtained when the operation was used in cases of gastric ulcer or hyperacidity. The invariably offered explanation for these results has been that the bile caused neutralization of gastric acidity, thus allowing the ulcer to heal. The results obtained in this and other experiments, however, have definitely shown that bile does not have any effect on the acidity of the stomach.

The results in the second series of experiments indicate that infection of the biliary tract and liver is the rule following this type of operation. The severity of the infections varied from only slight round cell infiltration to definite localized and miliary abscesses throughout the liver. Most of the dogs appeared to be in good health, but at exploration or necropsy varying degrees of infection were noted. In spite of the assertions to the contrary, I believe that the gastric contents enter the gallbladder in most cases; in support of this may be mentioned the presence of *Ascarides* in the gallbladder similar to those found in the stomach and intestine.

Clinical reports of the results following cholecystogastrostomy for ulcer of the stomach and hyperacidity without ulcer led to the conclusion that there is marked improvement in these patients with disappearance of most of their symptoms. Since it has been definitely shown that it is not the bile in itself which is causing the improvement, the question arises why such results are obtained. It is suggested that the attachment of the gallbladder to the stomach may slow and control gastric peristalsis mechanically, much the same as the speed of a motor is slowed by back gearing, thus accounting for the improvement.

Clinical literature on cholecystogastrostomy is lacking in postmortem reports in cases in which this operation was performed; so it is apparently not known whether or not infections of the biliary tract and liver develop. Wangensteen,[42] however, reported cholangeitis following cholecystoduodenostomy in a case in which the procedure was performed for a malignant lesion of the head of the pancreas causing obstructive jaundice. The patient lived a little more than a year, and during that time it was necessary to drain the hepatic ducts several times for relief from symptoms.

At necropsy the diagnosis of cholangeitis following cholecystoduodenostomy was confirmed. The absence of symptoms in the early stages is not an indication to the contrary, for the dogs in the second series all appeared perfectly well, and most of them gained in weight. The fact that infection developed in each of these dogs would lead to the assumption that the same process may occur in man. There can be no question that cholecystogastrostomy is the operation of choice in cases in which it becomes necessary to short circuit the bile because of irreparable obstruction of the common bile duct. This operation is justified in the presence of a malignant lesion of the duct causing obstruction, carcinoma of the head of the pancreas, stricture of the common duct and similar conditions. From the results of experimental work, however, it is ques-

42. Wangensteen, O. H.: Cholangitis Following Cholecystenterostomy, Ann. Surg. **87**:54, 1928.

tionable whether one should employ this operation in the treatment of patients with ulcer, hyperacidity or many of the other diseases for which it is advocated, in view of the great probability that disease of the liver and biliary tract will result.

SUMMARY

The literature pertaining to cholecystogastrostomy from both an experimental and a clinical standpoint is reviewed.

An experimental study of cholecystogastrostomy was undertaken to determine the effect of bile in the stomach on gastric secretion and motility, as well as the possibility of infections of the biliary tract and liver. Twelve normal dogs were studied in two series of six dogs each. In the first series, gastric digestion was studied by the McCann method of fractional gastric analysis for dogs. The emptying time of the stomach was also determined by means of the barium meal and the fluoroscope. Cholecystogastrostomy was then performed with double ligation and incision of the common bile duct. Following recovery, fractional gastric analyses were again made to determine whether the bile had any effect on gastric acidity. The results in the first series showed definitely that bile did not have any effect on the acidity of the stomach. The postoperative emptying time was essentially the same as the preoperative.

In the second series of dogs, gastric analyses were not made, but the same type of operation was performed as in the first series. The dogs were allowed to live under normal conditions for varying lengths of time and were then operated on to determine whether pathologic processes were developing in the gallbladder and liver. The results of the observations in the second series led to the conclusion that infections of the biliary tract and liver always occur following cholecystogastrostomy. It is suggested that the absence of clinical evidence of such infections does not preclude the possibility that pathologic changes in the biliary tract and liver are occurring in patients who have been subjected to cholecystogastrostomy.

A REVIEW OF UROLOGIC SURGERY

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KIDNEY

Surgical Technic.—Pérard [1] stated that fistulas are rather common following operations on the kidney and renal pelvis. To avoid a pus-producing fistula after operation on tuberculous kidneys, the ureter should be anchored to the skin. If a fistula should occur, it may be destroyed by the use of cauterizing agents. Certain fistulas cause large, deep, pus cavities which must be opened and healed by the use of tampons. Fistulas following ordinary pyogenic infections are quite rare and generally, if they do not respond to treatment, are due to the presence of a foreign body. Fistulas due to perinephritic abscesses continue if drainage is poor. Treatment consists of opening the abscess wide and breaking down any pockets that may be present. Urinary and pus fistulas can then persist only if there is a stone in the kidney, pelvis or ureter, or if there is ureteral obstruction in cases of hydronephrosis.

Urinary fistulas persist after nephrectomy if a certain amount of parenchyma remains, or if there is a vesico-ureteral backflow. Treatment in the first case consists in complete removal of the remaining renal tissue, and in the second, in either the use of a retention catheter or fulguration of the ureteral orifice. If the last two methods fail, complete resection of the ureteral stump should be undertaken. If this fails, the bladder must be freed on the normal side by ureterostomy. Fecal fistula usually occurs only after intestinal injuries. If the duodenum is affected, the patient usually dies of inanition unless gastro-enterostomy or cholecysto-enterostomy is carried out.

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1. Pérard, J.: Les fistules lombaires après les interventions sur le rein et le bassinet: leur traitement, Paris méd. **2**:115, 1927; abstr., Ztschr. f. urol. Chir. **24**:69, 1928.

Kaïris [2] stated that certain present-day surgeons, of whom Marion is a well known example, have done away, for the most part, with sutures in performing pyelotomy and ureterotomy. In a series of cases in which operation was performed in Joseph's clinic good results were obtained by not using sutures. In all of the cases there was urinary drainage for only a few days, and in three cases of pyelotomy there was none. These clinical facts were tested experimentally with dogs in which either a slit was made in the ureters or a small piece of the wall cut away and the wound left open. The sutureless wound healed as well as in the clinical cases. The scar was constantly quicker in forming, and after from two to three weeks it could be felt only as a small, firm line. Stricture was not noted.

Beer [3] stated that one of the difficulties in renal surgery is to decide whether the second kidney is really adequate. It is known that normal, although inadequate, secretion can take place from a hypoplastic kidney. The value of various tests can be experimentally studied on a kidney that has been nephrotomized and sutured. Beer examined one patient repeatedly following complete nephrotomy to determine whether that kidney was deprived of any functional ability. The percentage of urea concentration, the indigo carmine concentration and the phenolsulphonphthalein output were only slightly changed from that of the normal opposite side. About a month later, a differential phenolsulphonphthalein test was made, and the side operated on compared with the one not operated on as 45 : 65. Ten months later, the phenolsulphonphthalein was concentrated in six minutes on both sides. The ratio was 4 : 7.

Patel and Peycelon [4] reported a case of abdominal nephrectomy in which the vena cava was injured and consequently ligated. The patient recovered uneventfully. Procedures generally resorted to in such cases, such as compression, clamping, ligation and suture, were discussed. Patel and Peycelon preferred ligation as it is easy and quick and, if the hemorrhage has not been too marked, it is generally followed by good results. In cases of lateral contusion, a suture would be preferable. Various factors must be considered, such as the condition of the patient, the extent and site of the wound, the degree of hemorrhage and the accessibility of the vein. The authors stated that the anterior route is desirable in operating on large kidneys. Laceration of the vena cava could be repaired only with difficulty through a lumbar incision, and as

2. Kaïris, Z.: Ueber die Heilung von Wunden des Nierenbeckens und des Harnleiters, Ztschr. f. Urol. **21**:615, 1927; abstr., Ztschr. f. urol. Chir. **24**:70, 1928.

3. Beer, Edwin: Effect of Nephrectomy on Renal Function; Incision and Suture, Am. J. Surg. **4**:531, 1928.

4. Patel, M., and Peycelon, R.: Un cas de ligature totale de la veine cave inférieure pour une blessure opératoire survenue au cours d'une néphrectomie, Lyon chir. **25**:22, 1928.

laceration is usual in operating on a large pyonephrotic kidney, the kidney should be removed anteriorly.

Hunt [5] reviewed approximately 1,550 major surgical lesions of the kidney and ureter in patients operated on at the Mayo Clinic from 1922 to 1926. There were 916 nephrectomies, 127 (13.8 per cent) of which were for malignant lesions, with ten deaths (7.8 per cent).

In the upper part of the urinary tract, the lesions found in lithiasis comprised 55 per cent of the lesions for which major operations on the kidney and ureter were necessary and 49 per cent of the surgical lesions of the kidney. Single stones are usually situated in the pelvis and are readily accessible by pelviolithotomy. A bilateral operation is not indicated in all cases of bilateral renal lithiasis. In the absence of acute symptoms but with distinct evidence of marked difference in the amount of renal injury due to the presence of stones, it has seemed best to operate first on the kidney with the better function, in order to take advantage of the function remaining in the poorer kidney during the acute stages following operation. Nephrectomy was necessary in 229 (33 per cent) of the total number of cases of renal lithiasis. It is clearly indicated when the kidney is functionless as a result of calculi or when there is pyonephrosis or marked infection. There were five deaths following operation for renal stone and extensive infection. Conservative operations of pelviolithotomy and nephrolithotomy were performed in 440 cases and the combined operations in 417 cases. Pelviolithotomy is the operation of choice; it is least destructive to renal tissue. Stones were removed in 84 per cent of the cases by pelviolithotomy. Nephrolithotomy is usually done for stones in the ends of the calices.

Localization of shadows at operation is important in order to assure removal of all multiple stones. Braasch and Carman devised a method of fluoroscopic examination with the kidney elevated out of the wound at the operating table, which has proved valuable in the detection of small particles of stony material and has afforded reasonable assurance of complete removal of all stones before the conclusion of the operation. Fluoroscopy at operation has made possible the conservative operation of pelviolithotomy for multiple stones in cases in which nephrectomy was formerly necessary.

Seventy per cent of ureteral stones requiring surgical removal were situated in the lower third of the ureter. Hunt reiterated the importance of accurate localization of ureteral stones before operation. Ureteral and renal lithiasis on the same side occurred in fifteen cases, in ten of which simultaneous pelviolithotomy and ureterolithotomy were

5. Hunt, V. C.: The Upper Urinary Tract; a Consideration of Its Surgical Lesions, Northwest Med. **27**:213, 1928.

performed. In five cases complete nephro-ureterectomy was necessary. In twelve other cases, a ureteral stone had been productive of pyonephrosis in seven and of hydronephrosis in five, making necessary nephrectomy and partial ureterectomy to a point below the ureteral stone.

Associated tuberculous lesions were found in 80 per cent of cases of surgical renal tuberculosis. In the absence of general contraindications, this should not deprive the patient of the benefit to be obtained from removal of the major tuberculous lesion, if it is in one kidney. The low primary mortality rate following nephrectomy for unilateral renal tuberculosis justifies the operation, even if there is moderate pulmonary involvement. Diffuse miliary tuberculosis is considered a contraindication to nephrectomy. Renal tuberculosis formed the indication for nephrectomy in 258 cases, 28 per cent of the various conditions for which nephrectomy was necessary. There were six deaths, a mortality rate of 2.3 per cent. Indolent healing of the wound and a temporarily persisting sinus at times follow nephrectomy for renal tuberculosis. The ureter is usually thickened and dilated and, if not actually tuberculous, presents definite ureteritis, which has in many instances been the cause of a persisting sinus. Various methods of treating the ureter, such as injection of its lumen at the severed end with pure phenol, actual cautery sterilization of the stump, and bringing it to the surface of the skin and threading a tube over its end to carry subsequent drainage to the surface, have been advocated to prevent a postoperative sinus of ureteral origin. Walters showed that ligation and sterilization of the severed end of the ureter with the actual cautery is the most satisfactory method of treatment; a sinus persisted only temporarily in 25 per cent of the cases. A sinus of ureteral origin in the absence of a ureteral stricture rarely requires ureterectomy. It is inadvisable to insert drainage tubes after nephrectomy for renal tuberculosis, as it invites secondary infection, and a postoperative sinus develops with slow healing of the wound. Closure of nephrectomy wounds without drainage results in primary healing in a high percentage of cases.

Anomalies.—Alessandri [6] reported a case in which there was an anomalous orifice in the urethra of one of two left ureters and also a duplication of the right ureter and a bilateral double pelvis.

At operation the left kidney appeared larger than normal. It was composed of two parts separated by a groove. The superior segment, representing a third of the whole kidney, was composed of a thin layer of kidney substance and by a large dilated pelvis and ureter. The

6. Alessandri, Roberto: Bilateral Double Pelvis and Ureter with Anomalous Opening of the Superior Left Ureter into the Urethra; Congenital Ureteral Incontinence, Surg. Gynec. Obst. **47**:111, 1928.

inferior part of the kidney was apparently normal. Each section had its own vessels. The vessels to the upper segment were ligated and cut and the halves of the kidney separated. A V-shaped segment was removed from the lower half to permit good approximation of the sides of the incision. Recovery was uneventful.

[ED. NOTE.—Heminephrectomy such as reported by Alessandri has been carried out in comparatively few cases. On first thought, resection of the diseased segment of a double kidney seems to be a formidable procedure. When conditions are favorable, however, it does not offer any great technical difficulties and is followed by favorable results. The opportunities for the operation are limited, and the anatomic conditions are often not recognized. With proper suturing, postoperative hemorrhage should be negligible.

Removing a V-shaped segment from the lower portion in order to facilitate the closure of the wound was first practiced by Albarran in resecting the commissure of a horseshoe kidney. If infection remains in the tissues, a sinus may persist indefinitely and reopen at intervals. Often in these cases the groove which Alessandri mentioned is so deep that it almost bisects the renal mass. In other cases the capsule projects into the mass, causing an avascular area in the region of the groove or dividing point.]

MacKenzie and Hawthorne [7] reviewed the literature and reported six cases from the urologic service of the Royal Victoria Hospital at Montreal of developmental defects of the kidney with absence of function on one side. They described this condition as unilateral renal aplasia.

In the complete absence of the kidney, the renal bud apparently does not form from the wolffian duct. MacKenzie and Hawthorne added one case to the 350 or 360 cases of this type thus far reported.

A defect at a later period of developmental life would bring about the condition frequently seen if the kidney is absent, that of normal genital formation with a normal bladder and ureteral orifices, but with a short rudimentary ureter, which may or may not be patent. The short rudimentary ureter is fairly common. In many of these cases there may not be the slightest evidence of renal tissue, and this would indicate lack of development of nephrogenic tissue. A defect arising at a later period would leave a more perfectly formed kidney in a state of hypoplasia and without function.

The sole functioning kidney, under the load of carrying all of the excretory function, is often subject to injury by nephritis, calculus or

7. MacKenzie, D. W., and Hawthorne, A. B.: Unilateral Renal Aplasia, Surg. Gynec. Obst. **46**:42, 1928.

by infection. A more than normal percentage of persons with congenital solitary kidney die of renal complaints.

Three of the six cases reported were in males and three in females. The left side was affected in four cases, which agrees with the statistics from the cases in the literature. The symptoms which cause the patient to come for investigation are usually on the side of the remaining kidney, although in three cases pain was complained of on the side of the aplastic kidney. In all but one case, the frequency of urination, burning and pyuria were due to infection in the solitary kidney.

The bladder was symmetrical in five cases, and one case showed absence of the left ureteral orifice and the left half of the trigonal ridge. The right ureteral orifice was absent in one case complicated by vesicovaginal fistula, and in another case the left orifice was scarred and gaping as the result of an inflammatory lesion. The ureter on the side of the aplasia varied. In one case there was no evidence of an orifice. In three cases there was a short rudimentary ureter, which was patent for some distance. In two of these it ended blindly, and in one it was continued as a fibrous cord attached to the aplastic renal tissue found in that region. In two cases the ureter was present throughout and was dilated, thickened and filled with purulent material; in each case, it showed a stricture in its lower portion. Evidences of renal tissue were found in five of the six cases. This varied in type from masses of fat and fibrous tissue containing nests of epithelioid cells, small cysts and rudimentary glomeruli, to definite pelves (two cases) surrounded by a shell of tissue composed of connective tissue, tubules and a few glomeruli, many of which had been replaced by connective tissue.

Aplastic kidneys are functionless, although there is sometimes unexplained pain on the side of the aplasia. Operation and removal of the rudimentary kidney relieved the pain in two instances.

[Ed. Note.—The lesion of unilateral renal aplasia is doubtless more common than is generally believed. The condition bears some similarity, if not an embryogenetic relationship, to duplicated kidneys and polycystic disease, although in the cases mentioned, only conditions of unilateral aplasia in which the kidneys are more or less complete and functionless are considered. As a urologic problem, diagnosis is of the utmost importance, and the condition is to be borne in mind in differentiating occluded tuberculosis, atrophic pyelonephritis and postoperative or traumatic occlusion of the ureter.]

Papin [8] explored the right kidney of a patient, aged 21, who was suffering from pyelonephritis with renal retention. He found the kidney to be large, ptotic and malformed; its hilum faced anteriorly. The kidney had two vascular pedicles, an inferior accessory pedicle and a

8. Papin, E.: Un cas d'uretère borgne, Presse méd. **42**:665, 1928.

larger superior pedicle. The latter, before reaching the kidney, passed over a large elongated sac, which ended in a culdesac at its superior extremity. This sac was a duplicate ureter closed at both ends, the lower portion terminating at the bladder. This ureter, as well as the remaining ureter and attached kidney, was removed. Cystoscopic examination showed only two normal ureteral orifices; it had been impossible, either by cystoscopic examination or by the ureteroscope, to identify an orifice corresponding to the second ureter.

Ptosis and Perinephritis.—Scholl [9] stated that peritoneal tension due to a displaced kidney may at times obstruct the bile ducts and initiate a chain of symptoms such as pain, nausea and jaundice, which are indistinguishable clinically from true gallbladder disease.

The patient, a man, aged 55, had a fall which dislodged the kidney. He had had several attacks of severe pain in the region of the gallbladder associated with jaundice. Urologic examination revealed a large infected hydronephrotic sac containing stones on the right. The removal of this kidney caused all symptoms of gallbladder trouble to disappear.

During the course of the examination, the insertion of a ureteral catheter for drainage of the kidney caused immediate cessation of symptoms, including diminution of jaundice. Later the catheter was deliberately removed to see if this would cause a return of symptoms. A prompt return of pain and jaundice suggested a close causal relationship. A second ureteral catheterization again afforded relief and was continued until the time of the operation. Ureteral drainage not only gave the patient relief from symptoms but, by decreasing the size of the kidney and draining out most of its infected contents, the operative removal was facilitated and the possibility of contamination of the surgical field reduced.

The upper abdominal pain associated with secondary biliary disease is rarely as severe as that which occurs in acute gallstone colic, and it is usually relieved if the patient is placed in the prone position. The symptoms resulting from movable kidney are most common in thin, young women, and differ from those in the fleshy type of woman usually suffering from disease of the gallbladder. Jaundice is usually mild, intermittent and of short duration.

Tumors.—Judd and Simon [10] reported a case of angioma of the kidney. The literature on this subject is limited to single case reports. They reviewed eleven cases that are apparently authentic, and they reported one case of their own.

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9. Scholl, A. J.: Jaundice Due to Movable Kidney, California & West. Med. **29**:87, 1928.

10. Judd, E. S., and Simon, H. E.: Angioma of the Kidney, Surg. Gynec. Obst. **46**:711, 1928.

The patient, a woman, aged 57, had been having attacks of hematuria for twenty years. The bleeding was at times extremely abundant and associated with renal colic on the left side. Cystoscopic examination demonstrated that there was less excretion from the left kidney than the right; the left pyelogram was normal. In spite of a negative cystoscopic examination, the left kidney was explored and found to contain many dilated blood vessels in the superior pole. It was removed. A tumor 1.5 by 2.5 cm. was found in the cortex at the upper pole.

Microscopically the glomeruli were moderately sclerotic, especially in the region of the tumor where there was also moderate round-cell infiltration. The tumor was sharply demarcated from the renal tissue, but there was no evidence of encapsulation. It was composed of a network of capillaries and endothelial-lined spaces, filled with blood. The blood cells were for the most part well preserved but, in some areas, they had disintegrated, and considerable blood pigment was deposited throughout the tumor.

A distinction should be made between true angioma and other blood-containing tumors which may appear in the kidney. Carcinoma in which the spaces have become packed with blood cells is most likely to lead to confusion. Hemorrhagic cysts of the kidney are large and angiomas are small.

Cahill and Gile [11] reported a case of a large papillary carcinoma of the kidney. The patient, a negro, did not appear to be ill. Examination of the abdomen revealed a huge mass filling the entire left side and extending across the median line. A diagnosis was made of cystic kidney, and at operation a huge cystic mass was removed through a left rectus incision. Before the mass could be delivered, 6 liters of fluid was aspirated; more than 2 liters remained and was removed with the tumor. The patient recovered readily following operation and went home on the seventeenth day; the wound was firmly healed. The diagnosis was carcinoma of the kidney (papillary type).

Bumpus [12] reported a case of recession of pulmonary metastasis in a case of hypernephroma following nephrectomy. The kidney contained a large hypernephroma which filled the pelvis and extended into the pedicle and into the perirenal fat. A roentgenogram of the chest disclosed multiple metastatic areas in both lungs. Five months later the patient was feeling quite well, and another roentgenogram showed that all evidence of the former metastatic nodules had disappeared. Four years after removal of the primary growth, the lungs were still clear and there were no other signs of metastasis.

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11. Cahill, G. F., and Gile, H. H.: Papillary Carcinoma of the Kidney with Cystic Formation, Containing Over Eight Liters of Fluid, J. Urol. **20**:203, 1928.

12. Bumpus, H. C.: The Apparent Disappearance of Pulmonary Metastasis in a Case of Hypernephroma Following Nephrectomy, J. Urol. **20**:185, 1928.

Ljunggren [13] stated that he believed that the vagaries of time and appearance of hematuria in cases of renal tumors must be sought in the fact that the initial invasion by the tumor is often found in the most distal portion of a calix. These calices are frequently more or less dislocated, lengthened and compressed by the tumor, as is demonstrated in the pyelogram. Occasionally they may be entirely surrounded by the tumor. One such calix may easily be blocked by a small blood clot, so that blood does not enter the pelvis, and the urine clears suddenly. Such a process may explain a sudden increase in the size of the tumor by inward bleeding. The obstruction of a calix may become permanent, and a year or so later another attack of hematuria may occur, probably due to erosion of the tumor into another calix.

Schönheimer [14] stated that if hypernephroma originates from the suprarenal cerebroside, a chemical compound should be found as in tumors coming from the kidney. In 1909, Rosenheim and Tebb demonstrated its presence in the kidney.

Demonstration in a hypernephroma was carried out as follows: A large tumor weighing 2 Kg. was extracted for two months with acetone. The powder was completely extracted with ether and then treated with boiling alcohol. From the alcohol extract, a crystallized mass was obtained which was broken up with 1.5 per cent sulphuric acid. The galactose was isolated from the split end-product. It was identified in the form of its o-toluene-hydrazone.

Derman [15] reported a case of renal tumor in a man, aged 46. The growth was grayish-yellow and of cartilaginous consistence, with a smooth cross-cut surface; it was embedded in the parenchyma and renal pelvis. The original nidus of development seemed to be from the parenchyma, that is, the malpighian tubules; it then apparently invaded the adjacent tissues and metastasized into the epididymis. It is possible that the secondary growth may have reached the epididymis through the blood stream by means of the left renal or the spermatic artery. The growth appeared to be associated with much scarring and shrinking of the underlying tissues. The ureter was obstructed, causing hydronephrosis. Microscopic examination revealed a new growth of epithelial strands of cubical and cylindric cells. The diagnosis was "carcinoma scirrhoso-gelatinosum nodosum." The metastatic growth in the tail of the epididymis was similar to the original growth.

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13. Ljunggren, Einar: Ueber Hämaturien bei Grawitztumoren, Zentralbl. f. Chir. **54**:2272, 1927; abstr., Ztschr. f. urol. Chir. **24**:119, 1928.

14. Schönheimer, Rudolf: Beitrag zur Chemie des Hypernephroms, Ztschr. f. physiol. Chem. **168**:146, 1927; abstr., Ztschr. f. urol. Chir. **24**:20, 1928.

15. Derman, G. L.: Ein primärer gelatinös-scirrhöser Nierenkrebs mit Metastasen in die Epididymis, Arch. f. path. Anat. **265**:304, 1927; abstr., Ztschr. f. urol. Chir. **24**:132, 1928.

Cystic Disease.—Carson [16] reported four cases of solitary serous cysts of the kidney, adding these to the 141 cases that had already been reported. Three views are held concerning the etiology: (1) the growths are due to embryonal rests; (2) they are due to failure of union between the glomeruli and the collecting tubules, and (3) they are retention cysts.

They are usually unilateral, the cyst being situated at one pole. The size of the cysts varies from about 30 cc. to 16 liters. In the majority of cases, the contents are described as clear serous fluid. Various complications are sometimes found, such as malignant disease, stones and tuberculosis. The average age of the patients is about 45. The cysts are somewhat more common in women.

Carson expressed the belief that polycystic kidney, solitary serous cyst of the kidney and solitary hemorrhagic cyst of the kidney are all the result of congenital malformations of the kidney and that a solitary hemorrhagic cyst is formed in the same way as a solitary serous cyst.

[Ed. Note.—Solitary cysts occasionally present themselves as symptomless abdominal tumors. Prior to the period of pyelography, these cysts were not diagnosed before operation. At present, complete cystoscopic examination usually suggests the true diagnosis. The cyst may compress the renal pelvis either into an upper or lower position, or there is median or lateral displacement; the resulting deformity is outlined in a pyelogram. Usually there is no infection connected with the cysts, and at times at least two thirds of the kidney remains. These cysts can be resected readily, leaving a normally functioning kidney.

Echinococcus cysts are to be considered in all cases of large renal cysts. A number of such cases have recently been reported by Craig from Australia. In such cases, it is essential that the entire affected area be removed.]

Davis [17] stated that congenital polycystic kidneys are the most important deformities of the urinary system because of the extensive degree of involvement, the progressive character and the marked tendency to hemorrhage and infection. He reported a series of twenty-two cases.

The most conspicuous tissue changes in these kidneys are the incompleteness of development in the unit structures, the incomplete assembling, the cystic degeneration and the consequent pressure atrophy. The cysts are most common in the subcapsular zone at the line of fusion of the lobules. They occur in the capsular zone, cortex and medulla.

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16. Carson, W. J.: Solitary Cysts of the Kidney, Ann. Surg. **87**:250, 1928.

17. Davis, J. E.: The Surgical Pathology of Malformations in the Kidneys and Ureters; a Study of Twenty-Two Cases of Bilateral Polycystic Kidneys, J. Urol. **20**:283, 1928.

Davis concluded from his study that congenital polycystic kidneys are caused by defective protoplasm, which may be inherited or congenital and is chiefly manifested by delayed differentiation. Growth impulse, differentiation and cystic degeneration are not identically timed in both kidneys or in different parts of the organs affected.

Echinococcus Cysts.—Craig and Brown [18] reported several cases of hydatid disease of the kidney; this disease is distributed throughout countries that have become famous for wool-growing, such as Australia, from which country these cases are reported.

In twenty-eight (1.9 per cent) of 1,468 patients with hydatid disease admitted to the Royal Prince Albert Hospital during the last forty-two years, the kidney was affected. Sixteen cases were reported in this article; eleven of the patients were males and five were females. The average age of the patients was 40 years; the youngest patient was 9 and the oldest, 67.

The hydatid embryo may reach the kidney at the primary infestation. Secondary infestation of the kidney may occur from rupture of a hydatid cyst into some part of the blood stream. So many tumors may be present clinically that a diagnosis of secondary malignant disease is made. This type of multiple foci is usually found only at necropsy.

The kidney is rarely invaded from a perirenal source. The hydatid embryo is blood-borne in the same way as a bacterial infarct and, like it, usually comes to rest in the outer part of the cortex of the kidney.

The situation of the embryo determines the course of the disease. Those in the upper pole are more fraught with danger than those in the lower, because of the proximity of the liver and spleen. In the lower pole, when the spherical hydatid reaches the capsule of the kidney, there is expansion downward, and an enormous growth may take place without interference with the important organs. Local peritonitis sometimes occurs as the growth expands, and in one case acute obstruction resulted from peritoneal adhesions. In the middle part of the kidney the parasite expands until eventually the whole organ is destroyed. Displacement of the kidney rarely occurs in this disease; it is the hydatid that becomes displaced.

Hydatids of the kidney may be divided into two natural groups, according to the symptoms and the treatment. In one group the hydatids communicate with the renal pelvis and in the other they do not. Those which communicate with the urinary channels have been classified as open and those which do not, as closed.

Until a hydatid has ruptured into a calix, the symptoms are those of renal tumor only. It is characteristic that the tumor may be large

18. Craig, Gordon, and Brown, R. K. L.: Hydatid Disease of the Kidney, Surg. Gynec. Obst. **46**:668, 1928.

without disturbing the general health of the patient. When once the hydatid has burst into the urinary tract, the patient has symptoms of genito-urinary trouble. Hematuria, colic and the passage of daughter cysts either whole or collapsed are the three cardinal features of the history. The colic is similar to that caused by renal stone. Intervals between attacks vary from a few days to a few months, according to the relief of tension within the cyst.

Cystoscopic examination may reveal a turbid efflux from the ureter during an attack of hematuria. The mucous membrane of the bladder is rarely involved. Pyelography is of value when positive deformity is shown, but the absence of deformity does not exclude the presence of hydatid. In the diagnosis of the closed type of hydatid, the intradermal test of Casoni and the complement deviation test of Ghedini are of distinct value.

Nephrectomy is the operation of choice in cases of open hydatid. Marsupialization or nephrostomy after devitalization of the contents of cysts with solution of formaldehyde or alcohol is the safest and best operation for closed hydatid. Subtotal nephrectomy may prove a useful operation when the function of the other kidney is poor.

Operation was performed in thirteen of the sixteen cases in this series. There were no deaths due to operation.

Tapping as a therapeutic measure in such cases has become obsolete. The safest method to prevent escape of the contents of the cyst into the perirenal tissue is a two-stage operation. At the first step the cyst is exposed by the usual method and stitched to the abdominal wall. The wound through the abdominal muscles is left open and packed with gauze. From ten to fourteen days later, when adhesions have shut off the surrounding areas, the cyst is evacuated as described.

Farkas [19] stated that echinococcus infection of the kidney is rare. Israel did not find any in 2,000 operations on the kidney. Small vesicles and their contents are of diagnostic importance, as is eosinophilia. Usually the blood from the infected subject gives a strongly positive fixation reaction.

Farkas reported a case in which the patient had repeated attacks of renal colic. The urine contained many chitin-covered vesicles. A roentgenogram showed a calcified area in the liver. A left pyelogram showed some dilatation. The upper calix appeared to connect with a small cavity. Operation revealed a fluctuant cavity about 9 cm. in diameter in the upper pole of the kidney which contained many different sized vesicles. Treatment consisted of removal of the large cyst.

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19. Farkas, Ignácz: Entfernung eines Echinokokkus-Sackes ans einer Niere, Verhandl. d. deutsch. Gesselsch. f. Urol., 1927, p. 192; abstr., Ztschr. f. Urol. **24**: 111, 1928.

Stones.—Braasch [20] stated that in forty-five of 133 cases in which operation for renal stone was performed it was found advisable to remove the kidney. This is due in part to the fact that in cases of renal stone the condition is not diagnosed and treated in the earlier stages. One way in which greater accuracy in diagnosis can be secured is to examine the urinary tract by the roentgen ray in every case of abdominal pain which is not typical of a special lesion in the abdomen. In certain cases, renal stones are present for a long time without causing pain. In other cases attacks occur only at long intervals, and the patient forgets his pain or neglects to have treatment. Sometimes an operation is advisable. In some cases the stone is quite small, less than 1 cm. in diameter, and it is questionable whether operation is justifiable. If a stone has been present less than six months and if it is so small that it can be passed spontaneously, it should be left alone. In cases in which the stone is too large to pass spontaneously and has been discovered accidentally, operation should be performed at once because complications will arise later.

Braasch is opposed to nonoperative treatment or conservative measures in surgical cases of renal stone. A common reason for nephrectomy is a previous unsuccessful operation on the kidney. Removal of stones from a kidney on which an operation has been performed previously is often unsatisfactory, and the kidney is usually so badly injured that nephrectomy is necessary.

There are apparently two factors in the etiology of the formation of renal stones—infection and disturbance in metabolism. Infection is probably more common and occurs secondary to a distant focus of infection.

Medical treatment will not destroy renal stones already formed, and it is questionable whether anything can be done to prevent the recurrence of stones, either by medication or cystoscopic manipulation.

Braasch stated that fluoroscopy at the time of the operation aids in insuring the removal of all stones from the kidney. If fluoroscopy is not available, as a substitute a film may be placed back of the kidney.

According to Beer,[21] the object of operation for renal stone is to remove all calculous material and at the same time to spare the kidney so that there will be little if any injury to the functional parenchyma.

Beer emphasized the importance of a careful preliminary urologic study to determine whether the kidney is infected, whether it is functioning sufficiently to be preserved and whether the opposite kidney is

20. Braasch, W. F.: Calculi in the Urogenital Tract, Wisconsin M. J. **27**:199, 1928.

21. Beer, Edwin: Points in the Technic of Operative Removal of Kidney Stones, Ann. Surg. **87**:428, 1928.

present and functioning in case nephrectomy should be necessary. For instance, if a kidney is infected and the stone is removed by nephrotomy, sutures passed through the kidney may lead to secondary diffuse infection and subsequent sacrifice of the kidney.

If the stone is in a solitary kidney, the kidney should be handled carefully and not dislocated from its normal position, the operation being done in situ. Beer reported the results from a study of 271 cases of calculi. The use of pyelotomy has been increased during the last few years in preference to nephrotomy.

Beer advocated the inverted S-shaped incision in the lumbar region as giving the best approach to the kidney for the removal of stone. After the kidney is exposed the ureter should be isolated and a double loop of catgut thrown loosely around this to prevent fragments slipping into the ureter. The combination of nephrotomy and pyelotomy is sometimes indicated. It is surprising how readily stones of the most remarkable and distorted shapes can be removed through a large pyelotomy incision. Beer also advocated washing out the renal pelvis with a strong stream of water introduced through a catheter.

The use of roentgenograms of the kidney made at the operating table and developed immediately, while the operation is in progress, is advocated. This is to supplement the use of the fluoroscope, as advocated by Brewer and Braasch. As advocated by Quinby, a film may be used, a needle being introduced into the kidney to indicate the upper or lower pole and to give the operator some idea of the relative distance of any overlooked stones from this marker.

If pyelotomy is impossible, Beer performs nephrotomy. A soft rubber tube may be clamped around the renal pedicle to give hemostasis. Roentgen control may also be used here. The open vessels of a nephrotomy wound on the cut surface can be tied readily by passing a suture on a fine needle armed with catgut around the exposed vessel twice and then tying it. In closing the nephrotomy wound, as few sutures as possible should be used, to avoid infecting or strangling the parenchyma. If the capsule is still adherent, mattress sutures of chromic catgut may be used close to the incision, a few sutures being taken well in from the convexity and a few more nearer the convexity. If, however, the capsule has been stripped back, no such support is present to prevent sutures from cutting into the parenchyma, and in such cases it is important to underpin sutures either with fat or muscle.

Whether the pyelotomy incision is accurately closed or not seems unimportant. As a rule, plain catgut sutures are placed in the pelvic wall to approximate the incision, especially if a wide pyelotomy has been made. Before the pelvis is closed, the double loop of catgut on the ureter should be removed after careful palpation of the ureter above the loop for possible fragments.

[ED. NOTE.—Beer's article is an outstanding contribution on surgical technic in the removal of renal stone. The use of roentgenograms as an adjunct to fluoroscopy at the operating table is an advance concerning which we may hear more in the light of clinical experience. When the fluoroscope was employed at the operating table by Braasch and Carman, it was at once recognized as an important aid in detecting and removing small stones or fragments of stone. Just how much greater the value will be of the actual film taken of the exposed kidney over the fluoroscope is a question which time will answer.

Beer's closure of nephrotomy wounds by the underpinning technic is well known and frequently applied by American urologists. Unquestionably the method is of value in avoiding undue constriction of areas of parenchyma which later may undergo necrosis, with destruction of function, hemorrhage or infection.]

In studying the influence of operative procedures on renal function in nephrolithiasis and nephroptosis, Smirnov [22] came to the following conclusions:

In the majority of cases following pyelotomy, the function is increased over that of kidneys not operated on. Ureterotomy definitely increases the function of both kidneys. Nephrotomy does not decrease the function of a diseased kidney; the decrease of function observed after operation usually returns to the normal at a later period. Nephrotomy with the removal of large stones sometimes affords diminished function of the kidney operated on. Nephropexy not only brings about relief from pain but sometimes augments the function of the kidney operated on.

Infection.—Čajka [23] reported a series of cases of renal infection during pregnancy. His material consisted of seventeen cases of pyelitis, one case of pyonephrosis, and eight cases of pyelonephritis in pregnant women from the third to the seventh month. In seven cases, the pregnancy was the first. In seven cases the colon bacillus was the infecting organism, and in two cases the staphylococcus was found. Three patients made good progress on conservative treatment, among them being a woman at full term with her only kidney infected. Abortion occurred in one patient. Five patients were operated on, among whom was one patient with right pyonephrosis, and double pelves and ureters. The upper ureter opened at the external urethral meatus. There were three patients on whom nephrotomy and decapsulation were performed;

22. Smirnov, N. A.: Der Einfluss der operativen Eingriffe auf die Nierenfunktion bei Nephrolithiasis und Nephroptosis, Ztschr. f. urol. Chir. **24**:143, 1928.

23. Čajka, A.: Zur Frage der Diagnose und Therapie der Pyelonephritiden der Schwangeren, Verhandl. d. I. Kong. russ. Urol. **31**:131, 1927; abstr., Ztschr. f. urol. Chir. **24**:124, 1928.

bilateral operations were performed on one patient. Among the cases reviewed in the literature were several anomalous conditions, such as the absence of one kidney and double kidneys.

In all cases the infection was in the right kidney; it was bilateral in several patients. The question of abortion or operation on the kidney is still unanswered, surgeons favoring abortion and gynecologists, operation.

Beckers [24] stated that little is known of the influence of pregnancy on nephritis. Persons with renal disease who must avoid any excess are endangered by pregnancy. The strain of gastro-intestinal and circulatory disturbances, as well as increased renal activity, generally falls on the poorly functioning kidney. Usually gastro-intestinal disturbances cause danger by permitting the absorption of toxic materials and the transfer of the colon bacillus from the bowel to the kidney through the circulation. The axiom that the pregnant woman must eat for two is decidedly to be avoided. The pressure of the pregnant uterus against the ureters is also a source of trouble. The possibility must be considered that an already existing disease might be made worse and that a chronic renal lesion may result from nephritis of pregnancy. In some cases the influence of the pregnancy is slight, but in most of the cases there is an increase in the intensity of the symptoms, which may even lead to hypertension and uremia. Chloride retention is rarely dangerous and seldom threatens the life of the fetus. In uric acid retention, the outlook for the life of the fetus is poor. For the mother, the dangerous period is during the puerperium. Pruritus, visionary disturbances and retinitis may be mentioned; the latter is especially prominent in primiparas. The children are usually born dead, and eclampsia threatens the mothers.

To end pregnancy, therapeutic abortion under ether anesthesia is recommended. During pregnancy, when salt retention occurs, rigid dietary restrictions must be carried out. Milk diets are eliminated in lieu of a varied diet without salt. In nitrogen retention, Beckers advised strong catharsis and regulation of diet consisting of butter, vegetables and fruits. In severe cases, abortion is recommended. In cases of hypertension, phlebotomy is used, with removal of about 500 cc. of blood.

Strauss [25] reviewed the results in nineteen patients with well controlled bacterial urinary infection treated with neoarsphenamine. All of the patients had chronic infection, often of several years' duration.

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24. Beckers, Réne: Néphrites chroniques et gestation, Rev. franç. de gynéc. et d'obst. **22**:92, 1927; abstr., Ztschr. f. urol. Chir. **24**:115, 1928.

25. Strauss, Heinz: Neosalvarsan in der Behandlung von Harninfektionen, Ztschr. f. Urol. **21**:587, 1927; abstr., Ztschr. f. urol. Chir. **24**:83, 1928.

All known methods of treatment had been unsuccessful. Strauss attempted to bring out the definite indications in which the neoarsphenamine should be used. His observations led him to the conclusion that it is only successful in staphylococcic infections and that good results should not be expected in cases complicated by stone, prostatitis and spermocystitis as well as by the presence of an anaerobic infection or colon bacillus. In twenty-four of twenty-five cases following the initial injection of neoarsphenamine, the urine was changed from an alkaline to an acid condition.

Strauss does not subscribe to the widespread idea that benefits are to be derived from the formation of formaldehyde. Furthermore, he pointed out that the neoarsphenamine works in a double manner, as a disinfecting agent in the blood and tissues and by the formation of a germicidal substance in the urine. Injections of 0.15 Gm. of neoarsphenamine were given on three consecutive days.

Haslinger [26] stated that the contracted kidney which is the result of an acute inflammatory process in a kidney or which develops in the course of chronic renal infection is a distinct entity, different in causation, symptoms, pathologic change and treatment from the contracted kidney of nephritis. The process may involve both kidneys or only one. Infection limited to the kidney may in time affect the other kidney. The condition may develop as the result of a single or repeated infection, or as the result of a stone or of a chronic infectious process in the tonsils, teeth or genital organs. The histopathologic changes are characterized by the development of infectious, indurated, sclerotic lesions leading to shrinkage of the organ. Dilatation of the renal pelvis is fairly constant. Inflammatory perinephritic processes, as well as strictures of the urinary passages, are frequent forerunners of a pyelonephritic contracted kidney.

Among the symptoms are pain and fever, the latter especially in uremic states. Pus and bacteria in a catheterized specimen are significant. Functional insufficiency is common. Pyelography and ureterography aid in diagnosis.

Conservative treatment should always be attempted. This includes medical treatment, ureteral dilatations and pelvic lavage. Surgical procedures, in case of failure of conservative treatment to bring about improvement, consist of decapsulation, of freeing the kidney from pain-producing scars and of decapsultation combined with nephrotomy. Nephrectomy is indicated in only a few cases. In twenty cases observed by Haslinger in the Hochenegg Clinic, the colon bacillus alone was found in sixteen. In four other cases, bacteria other than the colon bacillus were present. Two patients were tuberculous. Four patients

26. Haslinger, K.: Die pyelonephritische Schrumpfniere, Ztschr. f. urol. Chir. **24**:1, 1928.

had stones in the kidney; one patient had a stone in the ureter. Five patients had ureteral stenosis, ten had infection of the genital organs, and four had perinephritic inflammation.

Hydronephrosis.—Wolotzki [27] noted that there are several other causes of hydronephrosis besides stricture, some of the more common and significant being kinks and angulations of the ureter. Wolotzki called attention to several normal ureteral constrictions, such as occur at the ureteropelvic juncture, in the area in which the ureter crosses the iliac artery and, lastly, at the wall of the bladder. His conclusions are as follows:

Among the causes of hydronephrosis, angulation and kinking of the ureter are significant factors. The cause of these pathologic ureteral changes may be considered congenital disturbances and acquired dystopia due to loss of fat or trauma, which may also act in conjunction with the renal pedicle and aberrant vessels. Treatment is purely on an etiologic basis and consists of correcting the cause, usually through plastic surgery. If the case has advanced to a hydronephrotic sac, nephrectomy may be necessary, except in cases of single kidney in which the treatment is nephrostomy; these conditions should be found as early as possible so as to institute early treatment. The pyelogram is of great value in making an early diagnosis.

Flandrin [28] operated in two cases of hydronephrosis reported by Fey. One patient, aged 19, had had symptoms of hydronephrosis for six years. The pelvis had a capacity of 13 cc., and it did not contract normally. At operation a large vein was found crossing the anterior surface of the pouch. It was cut and ligated. The capacity of the pelvis was reduced to 9 cc.

The other patient was a woman, aged 65, who had suffered for thirty years with right renal colic. Hydronephrosis was diagnosed, and at operation an inferior polar artery was found passing in front of the ureter. The artery was left intact, but nephropexy was performed which gave complete relief.

Renal Sympathectomy.—Hess [29] stated that the operation of renal sympathectomy is feasible, easy and practicable. By its use many kidneys which otherwise would be sacrificed can now be saved. Before the application of renal sympathectomy in the human being, it was necessary to consider whether a condition would be caused which might destroy the function of the opposite normal kidney, or whether it was

27. Wolotzki, A.: Ueber die Harnleiterabbiegungen und Abknickungen und ihre Folgen für die Niere, Ztschr. f. urol. Chir. **24**:173, 1928.

28. Flandrin: Deux observations d'hydronéphrose par vaisseau anormal, Presse méd. **59**:936, 1928.

29. Hess, Elmer: Renal Sympathectomy, J. Urol. **20**:333, 1928.

necessary to denervate both kidneys so as to reëstablish an equality of the burden. Both of these questions are answered in the negative.

Indications for the operation are as follows: nephralgia, unilateral hematuria, as an adjunct to the removal of stones in the pelvis of the kidney or ureter, anuria that lasts longer than a few hours, and possibly renal tuberculosis.

Hess carried out this operation in five cases. The technic is important: The kidney is exposed by any of the usual flank incisions. The perirenal fat is separated and the kidney delivered into the wound. The ureter is found and completely freed as far down in the pelvis as possible. An attempt is not made to conserve the blood supply, the nerve supply or the lymphatics in this freeing. The little vessels running into the parenchyma of the kidney, through the capsule, are sacrificed in the delivery. Retractors are placed in the wound so that the exposure of the pedicle is facilitated, and with gauze the pedicle is gently stripped of all of its fatty sheath, care being taken not to injure the thin-walled veins. This fatty sheath containing lymphatics and nerves is stripped as far down toward the aorta and vena cava as possible. The fibrous sheath surrounding the arteries and veins is gently teased away with forceps and stripped back away from the kidney. Small nerve filaments or lymphatics are picked up on a grooved director and cut until the vessels of the pedicle are left completely exposed on all sides from any fascial covering for a distance of at least 1.5 cm. and preferably farther.

Hess' five patients were relieved of their clinical symptoms. Kidneys which ordinarily would have been removed have been saved. Three patients were operated on more than a year before the paper was written and were free from their previous clinical symptoms. The amount of urine secreted by the sympathectomized kidney after six months is about one-fifth more than that of the opposite kidney. Hess had never denervated both kidneys.

Nothing has been developed to show that the operation has any influence on the opposite or normal kidney. Pyelography prior to operation caused nausea and in two cases vomiting, although small amounts of sodium iodide were used. After operation this syndrome was not noted in any of these cases at the time of pyelography. Difficulty had not been encountered in passing ureteral catheters after operation, and there seemed not to have been any evidence of kinking or stricture of the ureters such as is obtained in some of the cases prior to operation.

Lymphatic Drainage.—Syzganov [30] based his study of the lymphatic system of the kidney on the examination of the bodies of seventy-five

30. Syzganov, A.: Ueber das lymphatische System der menschlichen Niere, Verhandl. d. I. Kong. russ. urol. **31**:33, 1927; abstr., Ztschr. f. urol. Chir. **24**:4, 1928.

children. He employed red and blue injection masses, using Herot's technic. The right kidney possessed several efferent systems, which Syzganov divided into three groups: (1) the lymphatics of the superficial surface and also partly of the deeper and middle layers; the lymph nodes between the aorta and the inferior vena cava from the level of the left renal vein down to the bifurcation of the aorta; (2) the lymphatics of the middle layer and part of the superficial and deep layers; the lymph nodes of the spaces mentioned which lie in a deeper region, and the lymph nodes behind the right renal vein, and (3) the lymphatics of the deeper layer and the lymph nodes behind the renal artery.

The vasa efferentia of the lymph nodes of the spaces between the vessels end in glands which are in connection with the right and left lumbar ductus; some end directly in the thoracic duct. The left kidney possesses a greater number of efferent vessels, grouped as follows: (1) most of the superficial lymphatic vessels and part of the deep and middle sinuses; the lymph nodes which lie superficially on the left border of the aorta and beneath the left renal vein; (2) the middle and part of the superficial and deep vessels; the lymph nodes which lie anteriorly at the level of the left renal artery, and (3) vessels of all three layers; the lymph nodes lying along the left border of the aorta.

The vasa efferentia of these nodes help to form the left lumbar ductus, and some enter directly into the thoracic duct. The structure of the lymph channels of both kidneys is asymmetrical on account of the variation of the origin of both kidneys from the cisterna chyli and the beginning of the thoracic duct; also, there is a variation in the communication of the proximal channels with the neighboring organs.

The lymphatics of the right suprarenal gland, together with those of the right testicle, the undersurface of the right lobe of the liver, the undersurface of the right half of the diaphragm, the ascending colon, the cecum and the appendix empty into the lymph nodes of the right kidney. Into the lymph nodes of the left kidney empty the channels of the left suprarenal gland, the left testicle, the pancreas, the upper surface of the right lobe of the liver and the under surface of both halves of the diaphragm. Aside from these, there are connections between the lymphatics of both kidneys and the gastro-intestinal tract. In some cases the superficial lymphatic system of the intestine, ascending colon, cecum and appendix communicates directly with the right kidney. The lymphatics of the renal capsule are as side branches and communicate with the nodes lying between the aorta and inferior vena cava. Less frequently, the lymph channels of the anterior surface of the kidney communicate with the glands at the ileocecal juncture.

Injections of the lymph channels of the fibrous capsule were unsuccessful.

Hematoma.—Heilmann [31] removed a right kidney from an acutely ill man, aged 64. The kidney contained a large hematoma involving the entire fatty capsule. It arose from the surface of the kidney and was separated from it by a thin fibrotic layer. The parenchyma was macroscopically and microscopically normal. Small thin-walled vessels led from the margin of the kidney into the hematoma itself. These vessels were surrounded by a circle of polymorphonuclear leukocytes. An increase of the capillaries, hyperplasia of the endothelium or rupture of any larger vessels did not occur.

Heilmann considered the hematoma a massive capillary hemorrhage in the connective tissue and fatty capsule of the kidney. He accepted the theory of Rickers that this type of hematoma can be explained by vasomotor destruction and resulting diapedesis. He recalled similar hemorrhages in pancreatic apoplexy, idiopathic renal bleeding, a type of cerebral hemorrhage and internal hemorrhagic pachymeningitis.

Essential Hematuria.—According to Rømcke and Trygve,[32] there are cases of essential hematuria in which neither pathologic nor anatomic evidence is to be found, but such cases are gradually decreasing as diagnostic measures become more efficient. The diagnosis of essential hematuria should be made only as a last resort. The many causes of hematuria discussed in the literature should all be carefully considered. The authors discussed seventeen cases of their own which clinically were essential hematuria. Operation was performed in all cases and, with two exceptions, histologic examinations were made. The clinical symptoms consisted usually only of hematuria for a varying length of time (from several days to twenty years) and of varying intensity. Deficient renal function was not shown in any case. Hemophilia and hysteria were ruled out in all cases. Nephrectomy was performed in ten cases and in seven, nephrotomy and decapsulation. In one of the latter cases secondary nephrectomy was done. Seven patients were well after nephrectomy. One patient with continued hematuria had carcinoma of the prostate, and the results with regard to two patients were not ascertained. Following nephrotomy five recovered; one died following secondary nephrectomy, and the condition of one remained unchanged.

Histologic examination of specimens from fifteen cases revealed microscopic nephritic changes in five cases, the changes of pyelonephritis in one case and subcapsular bleeding in one; a definite change was not noted in eight cases. The nephritic changes consisted of interstitial round-cell infiltration. Definite glomerular changes were found in only

31. Heilmann, P.: Zur Frage der Perinephritis capsularis haemorrhagica, Zentralbl. f. allg. Path. u. path. Anat. **40**:185, 1927.

32. Rømcke, Olaf; and Trygve, Serck-Hanssen: Essentielle Nierenblutung, Acta chir. Scandinav. **62**:211, 1927.

one case. Rømcke expressed the belief that in the cases in which lesions were not demonstrable the pathologic process lay in another plane or was focal.

Suprarenal-Renal Heterotopia.—Caylor [33] reported a case of suprarenal-renal heterotopia (developmental inclusion of the suprarenal gland beneath the capsule of the kidney). The kidney was removed because of hydronephrosis. The anterosuperior surface of the kidney was covered by a yellow area, which was found to be the suprarenal gland. After the capsule was stripped from the kidney, the gland was found beneath it.

About thirteen cases of this condition have been reported in the literature. It is of surgical importance because with the removal of the kidney the removal of the suprarenal gland also might have an adverse result by reducing the potential production of epinephrine. Since the medullary substance is diminished, injections of epinephrine postoperatively may combat the evident insufficiency. In the case reviewed, it was impossible to save the suprarenal gland because it was wholly beneath the capsule of the kidney.

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33. Caylor, H. D.: Suprarenal-Renal Heterotopia; Report of a Case, J. Urol. **20**:197, 1928.

(To be Continued)

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